HARMSWORTH SELF-EDUCATOR

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THE PROGRESS OF CHARLES I. TO THE GUILDHALL TO DEMAND THE ARREST OF THE FIVE MEMBERS OF PARLIAMENT

From the Painting in the Royal Exchange by SOLOMON J. SOLOMON, R.A. [See HISTORY]

Baridbaran Mukerji.
1 College Row. Calcutta.

EVERY·DOOR·IS·BARR'D·WITH·GOLD·AND·OPENS·BUT·TO·GOLDEN·KEYS

HARMSWORTH SELF·EDUCATOR

A·GOLDEN·KEY
TO·SUCCESS·IN·LIFE

EDITED·BY·ARTHUR·MEE

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THE MAKING OF MEN & NATIONS

Human Nature and Society: Society and Human Nature. Men and Systems: Systems and Men. The Great Lesson of History. The Society that Endures

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By Dr. C. W. SALEEBY

LET us take a single contemporary illustration of the all-important proposition which is the central truth of sociology. There never yet was an autocracy or an oligarchy which did not depend for its existence upon an army. One man cannot defy the wills of millions merely because he is labelled emperor or king. He must have an army; as long as he has an army he will persist, and as soon as his army becomes disaffected, his knell is sounded.

The Russian Tyranny. Now, a society, if it is to produce an army devoted not only to aggression by the autocrat against foreigners, but also devoted to the control, and, if necessary, the destruction and murder of its own flesh and blood—the people from whom it has sprung—that society must be capable of producing a sufficient number of men whose nature is such that, so long as they are paid, they will not hesitate to trample upon the liberties of their own people. Thus, the very existence of a tyranny such as the Russian tyranny, which daily distresses every lover of liberty and of mankind all the world over, is in itself a demonstration of and a consequence of the existence of a certain kind of human nature among the Russian people. There is an all-important addition to be made to this proposition, and we are about to make it. Even in this present partial stage of analysis, however, the sociological phenomena presented by Russia will suffice, especially for any reader who has read the history of the French Revolution, as a fair illustration of our general proposition that human nature is the key to sociology—that the characters of a society depend upon the characters of its units in an infinitely more fundamental and necessary fashion than the characters of the molecule of a chemical compound depend upon the characters of its constituent atoms.

The Key to Human Nature. But man is a spiritual being, and not merely a dynamic mechanism like an atom. No chemist contends that there is any reaction of the molecule upon its atoms. The atoms and their relations determine the molecule, but the molecule does not modify the atoms. Immeasurably different is the case of society. Human nature, we have said, is the key to sociology, and this is true, but it is only half the truth: the complementary truth is this, that sociology is the key to human nature. That, perhaps, is a somewhat bald and imperfect way of stating the proposition, but we so state it in the hope that we may make it memorable. Our business is not to instruct, but to educate, and nothing could be more useless than that the reader should accept these propositions simply because they are to be found on this page. But here we submit them to him for his consideration and reflection: *Human nature is the key to sociology; sociology is the key to human nature.*

And now let us return to the illustration which sufficed in proof of the first proposition, but which we described as having been only half analysed. Now if the first part of our analysis was important, this is infinitely more important. It is interesting, doubtless, that the sociologist should find in human nature the key to the problems presented by societies. But we are not all sociologists, and this abstract proposition has no particular practical consequences for us. The converse proposition, however, which is the most generally and most fatally ignored of all sociological truths, concerns us all infinitely and vitally, as we shall now see.

A People Deserves What it Gets. It is an easy matter to say that the production by the Russian people of a brutal soldiery, which has hitherto been willing to militate against the happiness of the people from whom it has sprung, depends upon human nature as it is exhibited in the Russian people. It is even possible, judging by this and countless other illustrations, to say that, in general, a people deserves what it gets. For instance, only a superstitious people will be governed by such a priesthood as many of those which have darkened human life and served the devil since the dawn of civilisation.

Only a brutal people, again, can permit themselves to be dominated by a brute of their own race. Yet again, only a foolish and selfish body of voters will be led away by the lies of politicians so as to give power to unworthy, foolish, and selfish men. From democracy, autocracy, or priest-ridden societies—in short, from societies of all kinds, may be quoted proofs of the truth which leads us to say in such cases, "Serve them right." The impartial observer recognises that it does serve a people right to groan under this, that, or the other burden. It is a product of their own lack of courage, or wisdom, or honour. Indeed, to say that on the whole a people deserves what it gets—a proposition which has its light as well as its dark side, of course—is to say in other words what we have already said, that human nature is the key to sociology. This is a doctrine which everyone really admits, whether explicitly or not.

Heredity and Environment. But the thoughtful critic, looking upon the present unhappy state of Russia, and admitting that there must be brutal and ignorant elements in a people which produces an army for its own repression and grovels under superstition, will

ask *why* human nature in Russia is such and such. Now we know that the characters of any individual man or woman are determined by heredity and environment. There are inborn, inherent, innate characters with which each of us is endowed from the first: and then there are the modifications which circumstances or environment produce in us. Merely to say that human nature is the key to sociology and that the Russian people groan under the heel of the oppressor because human nature in Russia is capable of producing an army such as in all ages has been the necessary instrument of tyranny is as good as to say that human nature depends entirely upon the inborn characters with which each man is endowed from the first.

The Factors in Making Men. This, however, as we all know, is false. Environment plays its part in fashioning human nature. The body is determined by the atmospheric environment, by the nature of the food, by considerations of temperature, and the like. In this manner the inborn bodily characters are profoundly modified in every one of us. But what, pray, constitutes the all-important part of the environment of the mind? Buckle thought, as we have seen, that too much stress could scarcely be laid upon the presence or absence of mountains or earthquakes, thunder and lightning. Doubtless he recognised a truth of some importance; but nowadays we are sure that the forces which are most potent in moulding the spirit of man are themselves spiritual. Human nature is chiefly modified not by *natural*, but by *human natural* forces. It is the social atmosphere, the social environment, that is foremost in modifying the inborn characters of men. For instance, it has been finely said that genius can breathe only in an atmosphere of freedom. The superstitious régime breeds superstition; the brutal régime breeds brutality; in a military society the military spirit is fostered; and so in all other cases. After heredity, incomparably the most important of the influences which determine what a man shall be are the social influences, the social tradition, the spiritual atmosphere that he breathes.

Society Makes the Average Man. To take an instance, ambition will be all but impossible in a society where ambition is obviously futile. If there be no conceivable possibility that a man shall rise out of his class, the ambitious habit of mind will not be fostered in him. He will be different, in a word, from the man he would have become in a democratic society. Of course, we are not disputing the proposition that while most men are anvils and each must be either an anvil or a hammer, there are a few who are hammers, who make opinion, make tradition, and create new social forms and customs. Yet the fact remains that the majority of men are moulded by society into the form which suits its convenience, and tends to its own unchanged persistence.

The proposition that sociology is largely the key to human nature, as human nature is largely the key to sociology, is of profound interest to the sociologist as a pure man of science or seeker after truth. It invests his study with a unique interest and a unique difficulty. He has to study action and reaction. He cannot take the given facts of human nature, let us say, explain society in terms of them, and then be content. For the second and consequent set of facts react upon and modify the first.

Brutality Breeds Brutality. Thus, to turn to our Russian instance, the sociologist has to ask himself whether the characters of the Russian people—including the character of being able to produce a brutal soldiery—are inborn, necessary, and permanent, or whether they are not products of the brutal military régime. He has to inquire, indeed, whether any people, even the most democratic and freedom-loving—whether, indeed, such a people as ourselves, subjected for two generations to dominance by autocracy, militarism, and ecclesiasticism, would not in turn become capable of producing an army such as the Russian army. In a word, the sociologist has to deal with circles. Most of them in the past, alas! have been vicious circles. The superstitious or the brutal régime has fostered and produced the superstitious and brutal habit of mind which, in its turn, strengthens and makes possible that régime. Once we grasp the truth of the two abstract propositions upon which so much emphasis has been laid, we shall have acquired a wholly new means of passing sociological judgments. For instance, in his "Essay on Man," Pope writes:

> "For forms of government let fools contest,
> Whate'er is best administered is best."

To the untrained reader this may seem satisfying. If it be true it is a very important truth, but if it be false there is no more dangerous falsehood. The reader is well aware that, at any rate, it cannot be accepted without question, because it does not inquire into the effect of "forms of government" upon human nature.

The Failings of Democracy. Now let us see how the central sociological truths of action and reaction between society and the individual bear upon current political discussion. So far as the influence of human nature upon society is concerned, Pope's couplet will stand criticism. If there were no reactive influence such as we have described the couplet would be true. Everyone admits that forms of government, in order to be successful, or as successful as they are capable of being, are at the mercy of human nature, upon which their administration depends; and the great majority of untrained students of these subjects are content merely with recognising the half-truth which Pope recognised. For instance, sensitive people are sometimes shocked at the excesses, the blindnesses, the stupidities of which democracy is capable. Such people are apt to turn in disgust from the democratic ideal, and to declare that the best form of government, after all, would be government by a wise and beneficent autocrat, if such could be obtained. They see that democracy is liable to wire-pulling and the wiles of demagogues and the influence of wealth. They see, in short, that democracy may be very badly "administered," to use Pope's word, and they think that even

such a form of government as an autocracy would be infinitely better *if better administered.*

Government and Character. Now, we submit that all such opinions ignore the truth that different forms of government, even if all be ideally administered, differ profoundly in their influence upon human character. It is unthinkable that the same type of citizens could be produced under an ideal autocracy or hierarchy (government by priests) as under and in an ideal democracy. Different causes must produce different effects, and effects upon human character are the only important effects, perhaps, produced by any causes in the whole universe. The practical problem for the sociologist—who, as we have seen, is not merely a scientist or student of what is, but also a moralist or student of what ought to be—is to produce such a society as will make the best citizens. It is not merely his problem even to find the type of society which will keep human nature at its present level of intelligence and virtue. He knows that the average level is appallingly below the level of the highest, and he knows that, as Spencer somewhere says, what is possible for human nature here and there is possible for human nature at large.

Human Nature is Not Always the Same. The sociologist who is not a believer in evolution or the doctrine that progress is possible is, of course, a mere anachronism to-day. He is a survival from the intellectual atmosphere that preceded the idea of evolution, and, as such, is no more than an interesting and significant curiosity. If there be anything of which the sociologist is quite sure it is that, popular unwisdom notwithstanding, human nature is *not* "the same in all ages." He knows, on the contrary, that human nature is profoundly modifiable by circumstances. He knows that the ideal of human nature is vastly superior to the average reality, and yet he knows that the ideal is attainable. In passing his judgment, therefore, upon different forms of society, such as autocracy and democracy, or upon different theories of societies, such as individualism and collectivism, or upon social customs or Acts of Parliament, or, in short, upon one and all of the influences that determine the incessant changes of society, the wise sociologist asks himself what will be the effect upon the character of the citizen—the effect upon human nature.

A Nation is Made by its Units. There is one criterion alone by which the work of any and every social act is to be judged, and that is its effect upon individual character. Says Herbert Spencer, in words which should be written over the portals of every legislative chamber on earth:

"Let it be seen that the future of a nation depends on the natures of its units, that their natures are inevitably modified in adaptation to the conditions in which they are placed, that the feelings called into play by these conditions will strengthen, while those which have diminished demands on them will dwindle, and it will be seen that the bettering of conduct can be effected, not by insisting on maxims of good conduct, still less by mere intellectual culture, but only by that daily exercise of the higher sentiments and repression of the lower which results from keeping men subordinate to the requirements of orderly social life—letting them suffer the inevitable penalties of breaking these requirements and reap the benefits of conforming to them. This alone is national education. Of the ends to be kept in view by the legislator, all are unimportant compared with the end of character-making; and yet character-making is an end wholly unrecognised."

Why the Statesman Fails. The best form of government, then, is that which makes most rapidly and easily for the development of the highest worth in the individual citizen. We must later ask what is that form.

The only criterion of the worth of any society is to be found in the lives of its citizens. The great lesson of history is that other objects have been conceived as the proper objects of society, and that certain consequences have flowed from the pursuit of those objects. Let us compare and contrast the consequences which follow when other objects than the production of individual worth are sought by the statesman or the social reformer. We shall choose contrasted instances in the endeavour to show that it is utterly immaterial whether the object sought be good or bad in itself. In either case ultimate failure will follow.

History abounds with instances of societies or nations whose rulers have set certain more or less selfish objects in view and have for a time attained them. We know the history of empires; we know that, in the past, at any rate, unqualified Imperialism has always cut its own throat in the long run. We have various instances from all ages of governing powers who have set themselves to the production of powerful armies as means of conquest.

Militarism and Family Life are Eternally Opposed. To this end all legislative measures have been consecrated—or prostituted—and the end has been attained. Doubtless many other things have had to go—education has been one-sided, dealing with the body rather than the mind; moral education has dealt with the production of unquestioned obedience rather than with the production of a sense of personal responsibility for one's own actions; family life, with all that it implies in the ennobling of character, has been sacrificed, for militarism and family life are eternally opposed. Instances may be chosen on the small scale or on the large.

The reader was taught, perhaps, in his youth to admire the spirit of the Spartans who sacrificed everything to military efficiency. The Spartan mother sent out her son to war telling him to return with his shield or upon it—yet Sparta did not survive. In later times, when military warfare has yielded in part to industrial warfare, the men who have had the power to determine the form of society or of portions of society have instituted industrial régimes in which the sole consideration has been the efficiency of the

individual as a worker. These also have been successful in their way. When military efficiency was aimed at, it was often attained; when industrial efficiency is aimed at it may likewise be attained.

The Material of Empire. But the all important truth is that these objects, as such, are not worth attaining at their price. To obtain military efficiency or industrial efficiency, but to destroy the character of the people, is to achieve a temporary success at the rapidly ensuing cost of permanent failure. The material for any empire or society that is to endure is not money, nor red maps, nor mines that yield precious metals, nor treasuries mountains high, but worthy men and women. All the dead wealth on earth, accumulated and possessed and gathered into the hands of one worthless people, will not make an empire that can endure for six months. The legislator who legislates for anything less than character may be counted successful in his own day and even on the morrow; but he is not building for all time—and time will pronounce judgment upon him at the last.

The same truth is demonstrable in the case of legislation or other social action which, unlike that of the military dictator, is determined by sentiments of humanity and compassion. To-morrow as well as to-day has to be thought of, and the supreme factor of character remains supreme. It would be no more foolish than many acts which unwise people call charitable for the State at this moment to expropriate all the private wealth of the country, and to say "We will provide food, shelter, clothing, education, and a fair supply of amusements for all who please." Thereby many hundreds of thousands or millions of people, in this country alone, would be very greatly benefited indeed, for a time—they and their children too. A vast humanitarian end would have been achieved—for a time. There would be no more half-starved children—for a time.

A Passing Good and a Measureless Evil. An immediate good of some magnitude would have been accomplished; but if we are to form a final judgment upon this measure we must apply to it our criterion of its consequences upon character. The vast majority of men would not work unless they had to work—which is natural enough, since their work, unlike that of the fortunate few, affords them little or no spiritual sustenance or interest. Such men would cease to work under the measure we have imagined. Even supposing that the nation had some source of inexhaustible mineral wealth so that it could afford, as a nation, not to work, does anyone imagine that under these conditions the State would remain stable? On the contrary, the immediate good done would be as naught compared with the measureless evil which would be worked by such an act. It would involve the most appalling deterioration of character, resulting not only in the rotting away of the fibre of manhood, but also in the pursuit of pleasure by the many, under the conditions and with the consequences which are now exhibited in the case of the unemployed idle rich. Such a nation would cease to produce, or to be anything of worth, and the annexation of these islands by some Continental power would be a matter of a few years at the most. The little good accomplished would be far more than nullified by the evil influence of such a measure upon character.

Character the Sole Basis of the State. Anything that destroys the character of the individual destroys the State—which depends for its continued existence upon individual character *and nothing else*. If these propositions are true, it follows that the criterion of character-making or unmaking must be applied to all social acts by any whose concern is not with the immediate present alone. Here, again, of course, is another fundamental distinction between society and a mere chemical molecule. The present is the child of the past and the parent of the future, and to reckon with the present alone is to court destruction. The temptation may come in many guises, selfish and unselfish, but the criterion must be applied, and no measure which does not satisfy it must be allowed to pass uncondemned.

We have now completed, in so far as may be, what might be called the Philosophy of Sociology. We have tried to show the relations of the life of a society to the life of the individual; we have discussed the foundations of sociology and its relations to the lower sciences on the one hand, and to the supreme science on the other; and we have tried to distinguish between the attitude of the sociologist who asks himself merely what is and what has been and that of the sociologist who, being also a man with human emotions and aspirations, asks himself what ought to be; both of these attitudes being necessary, but neither being allowed to distort the view taken by the other.

Marriage the Central Institution of Society. We must now turn to the detailed study of our subject, and must begin with the fundamental social institution of marriage. We shall find it necessary here to begin our inquiry at a very early stage in the history of humanity. We must trace the different forms of marriage as they have been experimented with by man. We must inquire into their consequences upon society, and must determine, if possible—and it is not only possible but easy—which form of sexual relation is that best fitted to serve as the central institution of a stable and progressive society. This is a subject so important that the sociologist finds it impossible to suffer fools gladly when they discourse upon it, and being peculiarly intricate, difficult, and important, it is naturally a subject upon which fools think it well to expatiate.

Continued

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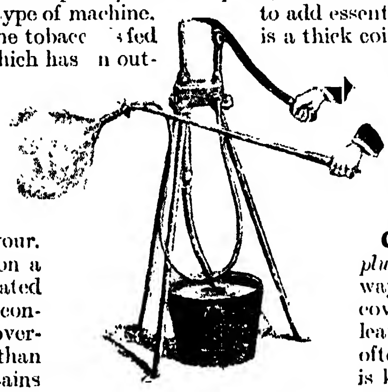
CIGARS, CIGARETTES, & PIPES

Manufacture of Roll, Twist, and Cake Tobacco. Snuff. Making and Moulding Cigars. Cigarette Machines. Clay, Briar, and Meerschaum Pipes

THE art of manufacturing smoking tobacco consists in selecting the different flavoured tobaccos and combining them to suit the various purposes for which they are required. As noted previously, ageing improves the tobacco, and sometimes the leaf is soaked in dilute hydrochloric acid to modify the nature.

Manufacture of Shag and Bird's-eye. After mixing, the leaves are damped, or *sauced*, with water in the United Kingdom, but in other countries sauces with flavouring ingredients are often used. The water is applied as a spray [7] or in the form of steam. When uniformly damped, the softened leaves are opened out, smoothed, and the midrib removed when *shag* is being made. The retention of the midrib gives *bird's-eye*. The leaves are then lightly pressed into a cake to squeeze out moisture, and cut up by a machine which works after the principle of a chaff cutter. In the modern type of machine, such as the Ajax cutter [9], the tobacco is fed continuously to the knife, which has an outward clearance movement on its upward stroke that prevents it rubbing against the tobacco, and thus avoids discolouring in the case of a bright tobacco. The cut leaf is then roasted, or panned, to dry and improve the flavour. The panning is done either on a rotating machine or on heated slabs, care being taken by constant turning to prevent over-scorching. Shag is stronger than bird's-eye, as the midrib contains a smaller proportion of nicotine than the fleshy part.



7. CLIMAX TRIPOD SPRAY PUMP

The tobacco termed *returns*, consisting of broken pieces of leaves and siftings, is similar to shag, but milder, although not so mild as bird's-eye. *Cut honeydew* is a strong smoke made from leaves of a light colour that have not been fermented to the same degree as those used for shag or bird's-eye.

Smoking Mixtures. Smoking mixtures of numerous virtues are put on the market. They are produced by mixing two or more different tobaccos. The following are examples:

Mild: York River, 4 lb.; coarse-cut British cavendish, 1 lb.

Milder but hotter: Bright returns, 5 lb.; Turkey, ½ lb.; light cavendish, ½ lb.

Full flavour: Returns, 5 lb.; cut cavendish, 2 lb.; Latakia, 1 lb.

Strong: Shag, 4 lb.; cut dark cavendish, 2 lb.

Many mixtures are much more complex than those shown in the above examples, but it will be noticed that certain tobaccos are used as bases and others for flavouring purposes.

Roll and Twist Tobacco. To make *roll* tobacco the darkest leaves are selected and stripped and sauced. They are then placed end to end, and twisted or spun into ropes of various thicknesses. The interior of the rolls consists of the small and broken leaves, the outer ones being usually bright leaves. The spinning process is effected either by hand or by a spinning machine [10], such as that used for making rope. The rope is rolled into cylinders or balls, which are enclosed in canvas and tied round with hemp cords. These masses are next stored in moist heat for some hours, and are then submitted to continuous pressure in hydraulic presses [8] for a month or so, when a slow fermentation takes place, and a good deal of the moisture is pressed out. To facilitate the spinning process and prevent the leaves caking together in the press, olive oil is used, and it is also allowable to add essential oils for flavouring. *Irish roll* is a thick coil, *pig-tail* a thin coil, and *brown tobacco* is one that has not been pressed after spinning. *Plug, bogie, nailrod, negro-head, ladies' roll,* and *target* are fancy names of roll tobacco for smoking or chewing. *Twist* ranges in thickness from the size of a bootlace upwards.

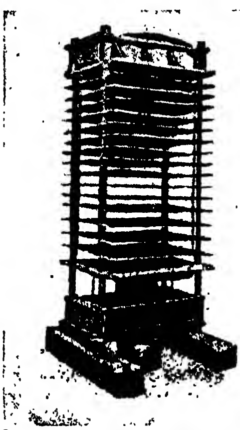
Cake Tobacco. *Cake* or *plug* tobacco is made in a similar way to that described above, the cover consisting of fine bright leaves. For chewing, the cake is often sweetened with liquorice, and is known as *sweet cavendish.* The sweetened cavendish is imported or made in bond, and can only be sold in stamped wrappers. The unsweetened cavendish is not subject to these restrictions. *Honeydew* is a light-coloured cavendish, and as *cut honeydew* is a strong smoking tobacco. *Varinas roll*, of Dutch manufacture, is not seen often now; it is a very mild cake. The twist and cake form of tobacco is much used by the working classes in Scotland and Ireland, as, besides being stronger than shag or bird's-eye, it is more economical, and also adapted for chewing.

Snuff. Although but little used at the present day, snuff-taking was formerly more in vogue than smoking. Up to A.D. 1700 snuff was used to ward off infectious diseases, but its popular use as a sternutatory is traced to a large cargo captured by Sir George Rooke off Cadiz, and sold off in English seaports at 3d. to 4d. a pound.

Snuff is made chiefly from the stalks and midribs of tobacco by a tedious process, during which fermentation is induced several times. The

coarse material of midribs and leaves is moistened with a solution of salt, and piled up into heaps containing many tons. The temperature rises gradually to about 140° F., and fermentation is allowed to proceed for some six months. At the end of this time the temperature begins to decline, and the heap is opened and the material ground to a light brown powder [11]. This powder is mixed with salt solution, and packed in large chests for six to ten months, when another fermentation occurs, and the powder develops colour and aroma. The snuff is well mixed, and sometimes submitted to a third fermentation. Finally the snuff is well sifted to make it uniform. It will thus be seen that the process extends over from 18 to 20 months, and consequently much of the nicotine is dissipated.

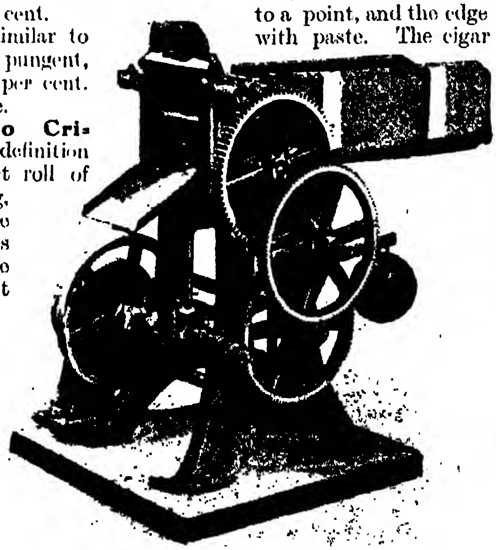
Rappee. *Rappee*, or *tabac râpé*, is a black snuff highly scented, and containing on an average 40 per cent. of moisture. The dark colour is due to long continued fermentation while in the bin. *Prince's mixture* is a rose-scented rappee, which takes its name from the fact that it was used by George IV. when Prince Regent. *Scotch and Irish snuffs* are made from stalks that have been previously roasted, which gives the characteristic smell to these snuffs. Scent is added to some varieties, and the moisture is generally about 20 per cent.



8. HYDRAULIC PRESS FOR ROLL TOBACCO

High dried snuff is similar to Scotch snuff, but more pungent, and with only about 5 per cent. to 8 per cent. of moisture.

Cigars—Colour no Criterion. The dictionary definition of a cigar is "a compact roll of tobacco leaves for smoking, one end being taken in the mouth, while the other is lit," and the word can be spelt in many different ways. A cigar consists of a core or filler, an inner cover, and an outer cover. The core should consist of the finest flavoured tobacco, and it is arranged in a longitudinal manner, so that the air can be drawn through it from end to end. It will be seen from this that the colour of a cigar is no guide to its quality or strength, which depends entirely on the quality of the filler or inside portion.

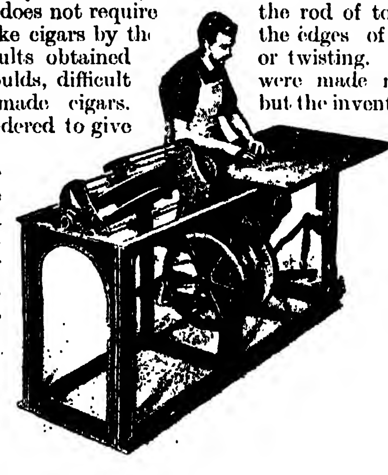


9. "AJAX" TOBACCO CUTTER

Making Cigars by Hand. In the handmade cigars workmen require years of experience before they can turn out well-made cigars; but of late years machinery and various pieces of apparatus have been employed to assist the operator. The making of cigars by hand can be thus described: The tobacco leaves are moistened by spraying to render them pliable, the stem is removed, and the leaves piled on the top of each other. The workman sits at a bench on which is a maple wood block, under which is a drawer for waste, and near him is a rack or box to receive the finished cigars. He is also provided with a knife for cutting purposes, a vessel of tragacanth paste for sticking the outer wrappers, and a cutter adjustable for various lengths—three to seven inches—with which to trim the end of the cigar to the proper length. There is a pile of wrapper leaf kept damp on one side, a supply of filler leaf on the other, and inner wrapper or binder leaf in front. A wrapper leaf is spread on the board, and cut into as many wrappers as it will make, the waste being pushed into the drawer. The binder leaf is torn into suitable pieces, and of these a large piece is laid on the board, and a smaller piece is placed on the top of it. The workman gathers up a handful of filler leaf, shapes it according to the kind of cigar required, puts it on the binder leaf, and rolls it therein. Care is needed to effect the packing and rolling easily, or a defective smoke will result. The outer wrapper is then rolled on spirally, beginning at the thick end, the mouth end of the cigar being manipulated to a point, and the edge of the wrapper touched with paste. The cigar is then trimmed to the desired length in the cutter machine.

Auxiliary Machinery. To assist the workman, suction wrapper holders and cutters are now employed, by which a saving of wrapper is obtained and a smoother appearance given to the cigar. Originally the suction tables were let out on hire, but they are now obtainable at much more advantageous rates. Some of these have a die for cutting out the leaf, but improved patterns employ a circular knife, so that the leaf is not torn at the edges [12]. Bunching machines are also employed, in which the filler is placed in a shaping cup, and by means of a concave roller and revolving apron the filler is quickly prepared in a suitable shape for binding. In another variety of bunching machine a pocket is formed in the apron, and no shaping cup is needed.

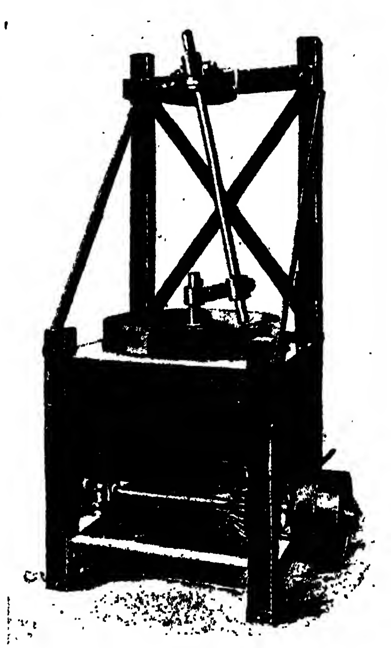
Moulded Cigars. In moulded cigars the bunches of filler are put into wooden moulds, some twenty moulds being arranged in each. The filled moulds are placed under a press for some hours, and are then ready for taking out and covering. Naturally it does not require such expert workmen to make cigars by the mould method, but the results obtained are, when using modern moulds, difficult to distinguish from hand-made cigars. The revolving mould is considered to give the best imitation of hand-made cigars. The hand-made cigar generally contains more tobacco than a moulded cigar. The moulds are obtainable in a great variety of shapes—the Miller, Dubrul, & Peters Manufacturing Co., of Cincinnati, illustrating in their list many hundreds of shapes and sizes [13]. The nearest approach to a machine for making cigars is obtained by combining bunching machines and moulds. The Reuse machine feeds the tobacco to two pairs of jaws, which form the core to any desired shape, and subsequently put on the binder and wrapper. A small mould is employed for shaping and polishing the point of the cigar. The Wartmann machine rolls the cigars between four rubber rollers, so shaped that a pocket is left between the rollers in the shape of a cigar.



10. GRIEG'S "SIMPLEX" SPINNING MACHINE

Finishing and Boxing. The cigars as turned out by the above processes are dried in the sun, or by a gentle heat, and sorted out according to colours, branded if needed with a hot brand, packed, and pressed into bundles or boxes. Before boxing the cigars a little perfume is sprinkled in the box. This perfume contains rum, lemon, cedar, vanilla, and other essential oils, the proportions of which vary, each maker having his own secret formulæ. The red cedar wood, of which the boxes are made, comes from Cuba, Mexico, and Central America, but the forests are rapidly being depleted.

Cigarettes. The consumption of cigarettes has increased so enormously of late years that it is difficult to realise that cigarette-smoking is quite a modern habit. The fashion was set by the soldiers who returned from the Crimean War, where circumstances had necessitated the use of tobacco in the form of cigarettes, and preference clung to the habit so formed when the necessity for it had vanished.

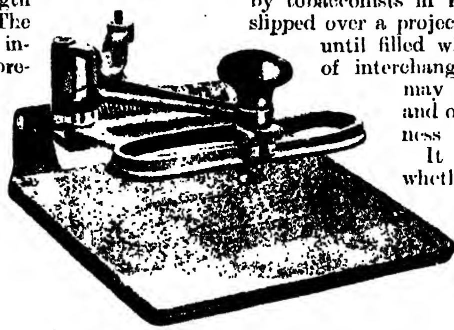


11. SNUFF MILL

Cigarette Making. The art of making a cigarette is first to prepare a sufficiency of tobacco in the form of a rod, and then to enclose the rod of tobacco in rice paper, fastening the edges of the paper together by pasting or twisting. Cigarettes up to recent years were made mostly by the smoker himself, but the invention of automatic machinery has transferred the operation to large manufacturers. The evolution of the cigarette machine is a striking instance of the perseverance of inventors and of ultimate success.

Single Cigarette Machines. The simplest type of cigarette machine is that in which single cigarettes are made, this type being divisible into two: (1) Machines in which the tobacco is prepared and encased in rice paper; and (2) machines in which the plug of tobacco is stuffed into a ready-made tube of paper. It will be noted that the efforts of inventors were very modest at first, the manufacture of cigarettes following strictly on the lines of the hand-made article. As an example of the first type of single cigarette machines may be cited the Evans Concinnum machine [14], which first appeared on the market in 1877. In this the tobacco for one cigarette was arranged on a grouping of small, corrugated rollers driven from a central wheel. The tobacco being neatly arranged, a cigarette paper was introduced, the lid closed, and then one turn of the handle wrapped the paper neatly round the tobacco. The makers of this machine claim that an expert operator can turn out 150 to 250 cigarettes per hour. A more ambitious machine on a similar principle was that of F. J. Ludington, invented in 1891. In this the tobacco was rolled and the edge of the wrapper pasted automatically. The next step is shown in the Lemaire machine, in which the cigarette filler is cut into lengths before being rolled in paper and the edges of the paper pasted, it being claimed that less waste and no loose ends result from this method. In the Williams machine the tobacco is fed to automatic mechanism and predetermined charges severed and conveyed to the rolling apron, there being mechanism for cutting the wrappers and pasting the edge, air suction being employed to

keep the papers flat. Girard, in 1895, with a view to quickening the process, devised a movable part in the mould, through which the cigarette was ejected by a jet of air. In this machine also the edges of the paper are folded. Grouvelle and Belot devised a machine for making four cigarettes at a time, the rolling being in imitation of the fingers by means of oscillating hinged levers. In Wood's machine the paper is fed to the machine from a roll, the width of which is equal to the length of the finished cigarette. The Hilgartner and Walker invention is an attempt to prepare the tobacco more carefully before cutting it into proper lengths and feeding it to the rolling table.



12. DUBRUL SUCTION WRAPPER HOLDER AND CUTTER

Plunger Type Machines. The Pierrot Minnot machine, invented in 1884, may be taken as an early example of the plunger type machine. The tobacco is brought down from a receiver between two endless bands running at different speeds to equalise the thickness of the layer. The tobacco thus carried forward enters laterally into a mould, the bottom of which rises to detach and compress the quantity to form a cigarette. A strip of paper to form a mouthpiece is twisted into form within the mould and is carried upwards with the tobacco when the mould closes. A piston then advances and pushes the contents of the mould out endwise through a tube or sheath, on which a paper wrapper has previously been arranged. Nippers hold the wrapper upon the sheath, and at the proper time allow it to pass forward, so that it may receive the tobacco within it and also the mouthpiece in its proper position as these are thrust out of the mould by the piston. The end of the cigarette is received by scissor-like cutters which remove the superfluous tobacco. The wrappers to be filled are taken from a magazine by a skewer-like instrument, which passes through a wrapper, removes it endwise from the magazine, and carries it to a sheath; then a slider on the skewer pushes the wrapper off endwise and transfers it to the sheath. The inventor claims that this machine will make 15,000 cigarettes a day. The machine has since been improved in respect to the mechanism by which the proper quantity of tobacco is detached from the mass before compression in the mould. Deconflé's machine of 1886 makes paper tubes with interlocking edges unpasted. These tubes are then placed on the end of a funnel and the tobacco contained in the funnel pushed into the tube by means of a plunger. The Georgii machines are of this type; the tobacco is rolled in an apron, and the charge pushed by a reciprocating plunger into finished paper tubes. The Ollagnier machine requires hand work to judge of the quantity of tobacco for each machine, the charges being then rolled and introduced into paper tubes. Grouvelle and Belot also adapted the plunger device for a machine making two cigarettes at a time. To the plunger type also belong the Jasmatzi, Bergstræsser, and Pederson machines. The New Transporter machine is one which is largely used by tobacconists in England. A paper tube is slipped over a projecting funnel and held there until filled with tobacco, and by means of interchangeable parts the cigarettes may be made circular or flat and of different degrees of thickness.

It is an interesting problem whether this type of machine will outlast other kinds referred to in this lesson. It is certainly at the present one of the most popular types.

Paper tubes for cigarettes are made in continuous lengths, the Bruandet machine being capable of making daily a length of tube corresponding to half a million cigarette tubes. Separate machines cut up the tubes, and in some factories a special machine is used for opening up the flattened tube before filling it with tobacco.

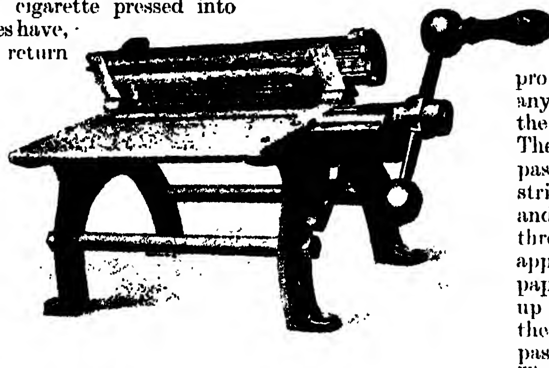
All-tobacco and Folded-end Cigarettes. All-tobacco cigarettes, in which the outer wrapper is cut from cigar leaf, are necessarily made on single cigarette machines, apparatus being provided for cutting out the wrappers. It is necessary to exercise care in cutting up a leaf of tobacco to avoid the heavy veins and midrib. A difficulty is often experienced in fastening the wrapper properly. A tragacanth paste is the best adhesive to use. The Hayden cigarette machine is one which folds in the end of the cigarette after the manner of Spanish, Cuban, or Mexican cigarettes. No paste is used on the paper wrapper, a twisting motion sufficing to hold the wrapper securely. This is done to enable the user to readily open the cigarette, as it is customary for users of this form of cigarette to roll the tobacco by hand before smoking.

13. DUPLEX LID CIGAR MOULD

Conical and Oval Cigarettes. The shape of cigarettes is not always round. One of the Bonsack machines is devised for conical cigarettes, users of this shape of cigarette contending that there is less waste of tobacco in the end thrown away. The oval, flat, or elliptical cigarette is growing in favour, the shape being better adapted for holding between the lips. The seam of the paper wrapper is generally on the flat side, but it is suggested that an improvement would be to make the seam on one of the narrow edges. The tobacco as prepared for the machine

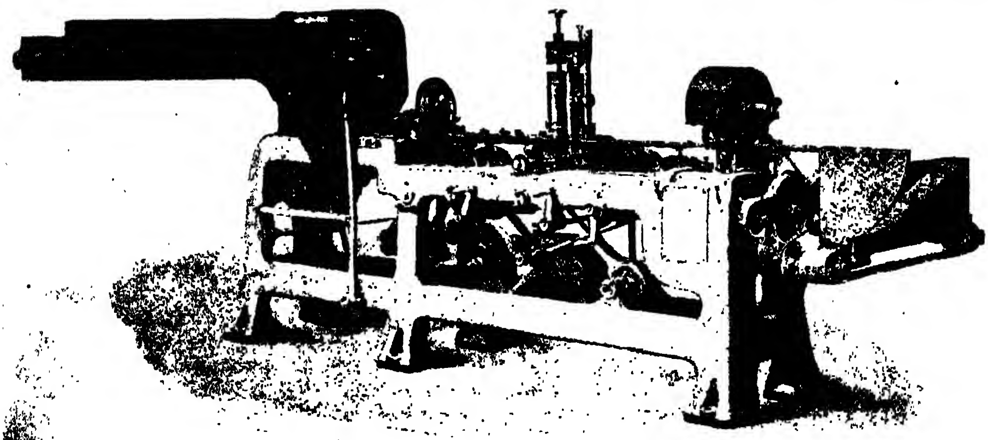
is of a round section, and must be separately moulded to the required elliptical shape. One of the Elliott machines has been adapted to this purpose, and one of the well-known Baron machines moulds the tobacco rod to an elliptical shape before wrapping. In the Braunstein and Chambon machine the tobacco is introduced into the paper tube by a spiral or screw arrangement and the finished cigarette pressed into oval form. Such cigarettes have, however, a tendency to return to their original shape.

Mouthpieces. To prevent cigarettes adhering to the lips they are provided with mouthpieces. These may be made by bronzing or waxing the end of the paper or by attaching a separable mouthpiece. Mouthpieces of stouter paper than that used for wrappers are dipped or brushed with melted paraffin wax, which gives them a translucent appearance and is quite effectual in preventing the cigarette sticking to the lips. Special machines are used for making and attaching mouthpieces, one kind also removing a little of the tobacco from the end of the cigarette and inserting a small plug of cotton-wool.



14. EVANS CIGARETTE MACHINE

Continuous Cigarette Machines. The machines in which a long row of tobacco is encased in paper—the operation proceeding indefinitely—and then cut up into cigarettes mark a distinct advance [15]. The Elliott machine, invented in 1890, started with the loose tobacco, which was spread in a layer, parted into windrows of uniform width and quantity, and pressed into continuous compact ropes or rods of tobacco. The wrapper was then applied and pasted suitably. In the Bohl machine of 1893 the tobacco is fed forward upon an endless carrier belt moving upon a horizontal table, and is brought to the middle of the belt by converging guard-plates, and then pressed sideways between two pressers moving towards each other. The tobacco then passes between converging spring guides to a series of pairs of grooved shaping-wheels on vertical shafts, by which it is pressed into an endless rope. Running along the upper surface of these wheels is a horizontal endless belt. Scrapers of special form and arrangement are provided to remove any matter adhering to the shaping wheels. The tobacco then passes on to the endless strip of cigarette paper, and the two pass through the forming apparatus, by which the paper is gradually bent up and folded round the tobacco and finally pasted and pressed. The adhesive is applied to the pasting disc by means of an endless thread running through the paste reservoir. After the endless cigarette is formed, it passes to a cutting apparatus, consisting mainly of a rapidly rotating disc cutter carried at the end of a revolving arm. In 1893 was introduced the Sloan & Barnes machine, in which the ribbon of paper is fed round the rope of tobacco in a spiral manner. The inventors likewise improved the manner of preparing the filler. The Maxfield machine also applies the paper spirally. The next step in the evolution is the abandoning of the use of paste for sticking the edges of the paper horizontally applied. Paste impares the flavour of the cigarette, and Munson's machine provided an interlocking device for the edges of the paper, the seam being afterwards crimped to make it hold. The Allagnon method of closing the edges is by two pressures on the seam, one being by means of a toothed disc. Kirshner also claims



15 DUBRUL'S PAPER-CIGARETTE MACHINE

an indenting or crimping device for holding the edges together, adaptable to the Bonsack machine.

Obviating Frayed Ends. Of the many attempts to prevent tobacco fraying from the ends of cigarettes may be mentioned Lumley & Taylor's machine. In this the arrangement for cutting up the continuous rod is so devised that it clears the tobacco away from the space about to be cut. One of the greatest difficulties that have had to be overcome in this type of machine is in the apparatus for carding or combing the tobacco to equalise it before forming it into rope. If the supply of tobacco be unequal, it gives a rope of unequal density, which shows itself in cigarettes that are difficult to draw. The Bonsack machine is one in which the mechanism in this respect has reached a high pitch, one of these machines being adapted equally for long or straight cut tobacco or granular tobacco.

PIPES AND PIPE MAKING

The materials of which tobacco pipes are made are of various kinds—clay, wood, meerschaum, asbestos, and metal. Baked clay is probably the oldest material of which pipes have been constructed, and the manufacture of clay pipes therefore will be considered first.

Clay Pipes. The clay from which pipes are made is a soft clay nearly free from iron, lime, and magnesia, so that it is colourless when baked, and very refractory. Broseley in Staffordshire, Purbeck in Dorsetshire, and Glasgow are centres of clay-pipe manufacturing. There are two main processes employed in the making of clays—namely, *pressing* and *moulding*. Pressing is mostly done on the Continent, and is rapidly dying out as the results are very unsatisfactory. In moulding, the clay is first of all weathered and matured till on the addition of water it can be kneaded into a smooth, homogeneous mass, sufficiently tenacious to hold together readily. A mould of steel or brass is prepared which represents each half of the clay pipe cut longitudinally down the centre, a brass block occupying the place of the inside of the bowl. Clay is laid in this mould and pressed, the block being inserted, so that the result is an exact half of a clay pipe. If two or more such moulds be prepared—in actual manufacture each mould consists of a great number of half pipes—and laid together so that the edges of the clay bowls and the flat sides of the shanks, which are solid, are in apposition a complete pipe is formed, a wire being passed down the centre to make the bore. The press is then opened and the pipe removed. Another workman trims off the rough edges and pulls out the wire from the stem. The pipes are allowed to dry in the air for some time, and are then baked.

Firing. The pipes are stacked in a large firing oven, similar to the ovens in which earthenware is baked, and the heat gradually brought up to a red heat. After a period of firing, which varies according to the kind of clay, the fire is allowed to die out, and when cool the pipes are removed from the oven.

Shiny clays are treated, before baking, with a lead glaze, such as is employed in glazing pottery, but some clays receive a natural glaze from the mould which is retained even after firing.

The mouth end of the pipe is tipped with sealing-wax dissolved in methylated spirit. The moulds for pipes are of various patterns. In the list published by McDougall & Co., of Glasgow, over 400 different kinds are quoted and figured. Pipe-making machines are also employed, one of the best being that invented by Mr. Young, of the firm of Davidson & Co., of Glasgow.

Briar Pipes. Wooden pipes are made of various hard woods, the chief being briar or bruyère root. This wood is used on account of its incombustibility. Briar wood has no connection with rose briers, but is the root of *Erica arborea*, a species of heath, which is grown in France, Italy, and Corsica. Centres of the briar pipe industry are St. Claude, Jura (France), and Nuremberg. The pipes are finished and fitted in London, but much briar wood is now obtained in Scotland and made into pipes in England. The roots are shaped roughly into the form of pipes, and then simmered for twelve hours in a vat, which has the effect of imparting the much admired yellowish-brown tint. A good pipe needs to be free from flaws, and as only about 10 per cent. of the pipes made fulfil this condition, it is not difficult to understand why a good briar pipe is expensive. The flaws in second quality pipes are stopped up with a composition, but the difference is apparent after the pipes have been smoked a few times. The rough blocks are converted into pipes by a process of turning and grinding.

The other woods used for pipes are the Mahaleh cherry, which grows near Vienna, the mock-orange of Hungary, the jessamine sticks of Turkey, Australian myal wood, and ebony.

The Hookah of the East. Mention may here be made of the hookah or water pipe preferred in Oriental countries. This smoking apparatus consists of three parts: (1) The head or bowl; (2) the water bottle or base; and (3) the flexible tube and mouthpiece. The smoke passes through water, and hence is quite cool by the time it reaches the mouth.

Meerschaum Pipes. Meerschaum is a hydrated magnesium silicate which, from its appearance and lightness, has become known as "sea-froth." It is found in Asia Minor (the plains of Eski-shehr), at Negroponte and Samos (Greece), and in California and Spain. The meerschaum is made into pipes at Vienna and Ruhla in Thuringia, whither it is imported in the rough state. The irregular blocks of meerschaum are scraped to free them from their red covering, dried, and polished with wax. The pipe-bowls are also soaked in melted stearine, wax, or spermaceti after they have been turned and carved. The reputation of meerschaum has declined of late years, but some smokers are still proud of the colour they have obtained on a well-smoked meerschaum pipe.

TOBACCO *concluded: followed by* FORESTRY

continued from page 4231

THE RAILWAY STAFF

The Three Divisions of the Railway Staff. Conditions of Entrance. Pension, Provident, and Insurance Societies' Funds

By H. G. ARCHER

THE number of persons employed by railway companies in the United Kingdom is known accurately for certain years only. The last official return is still that for 1901:

Stationmasters	8,103	Passenger guards	7,291
Brakesmen and goods guards	15,708	Signalmen and Pointsmen	28,496
Permanent way men	66,621	Labourers	53,282
Gatekeepers	3,507	Ticket collectors and examiners	3,642
Engine drivers	25,556	Mechanics	81,440
Porters	55,276	Other classes	185,216
Shunters	10,841		
Firemen	24,083		
Inspectors	6,772	Total	575,834

The Three Divisions of the Railway Staff. The staff of a railway is divided as follows:

1. Salaried officers and clerks, commonly called the clerical staff.

2. The "weekly wages" staff, sometimes referred to as the "uniformed" staff, although many of its members do not wear uniform.

3. The "daily wages" staff.

A hard-and-fast line is drawn between classes 1 and 2. If a man elect to join the "weekly wages" staff, he is seldom allowed to transfer his services to the clerical staff, although, of course, he may be promoted from the latter to the former. At certain points the two classes overlap. For instance, a first-class stationmaster is a salaried official, whereas a second-class stationmaster is in receipt of a weekly wage. If a man joins the clerical staff he is not supposed to exchange into the "weekly wages" staff; he may do so, but such exchanges are not encouraged by the authorities. The two classes do not mix.

Persons are admitted to classes 1 and 2 as juniors from 14 to 16 years of age, and as adults from 18 to 30, and in certain cases to 35 years of age.

The Clerical Staff. The clerical staff is open to all. No form of nomination is required; but some companies make it a rule to reserve a quota of vacancies for sons and near relatives of past and present officials. Again, where the latter practice does not exist, it is only natural that a claim of the above kind should carry influence.

Junior candidates for railway clerkships must produce good references, together with a medical certificate of sound health, and undergo an entrance examination (which is often competitive) in writing, spelling, geography of lines of communication, arithmetic, bookkeeping, shorthand, etc. As to what department a successful candidate is posted depends upon the nature of the vacancies at the time. A small station is the best place for a lad-clerk, as there he will learn parcels, goods, and passenger service work, together with telegraphy, etc.; in short, pick up a bit of knowledge about everything. The young railway clerk may, however, find himself posted to any one of the departmental offices—namely, that of the general manager, goods manager, superintendent of the line, or secretary, etc.

Examinations. When 18 or 19 years of age, he is called upon to pass the senior clerks' examination, and also a stiff medical examination by the company's doctor, the latter in order to qualify for admittance to the company's superannuation fund, membership of which is obligatory upon every salaried servant.

Adult candidates for railway clerkships have to pass the senior clerks' examination, and also the above medical examination, unless they be above a certain age—the usual limit being 28—in which case they are disqualified from enjoying the benefits of the superannuation fund.

"Weekly Wages" Staff. Lads are appointed to the "weekly wages" staff, provided that they have good characters and sound health, as vacancies occur. No formal educational examination is demanded of them. As a rule, a divisional inspector examines the lads in order to see that they are fairly intelligent and able to read and write. The majority of youths join the traffic department as lad porters, telegraph boys, van boys, and other similar appointments, while those who enter the locomotive department begin as bar boys or cleaners. On arriving at the age of 18 every member of the "weekly wages" staff has to undergo a searching medical examination, together with a test for colour-blindness, which is a fatal defect in a railway servant. Upon a successful issue depends his continuance in the company's service and admittance to the provident society, membership of which is compulsory. A large number of railway servants, however, join the "weekly wages" staff as adults, between the ages of 18 and 30, and they, too, have to possess a fair education, sound health, and freedom from colour-blindness.

Mechanics. In the Board of Trade return for railway employees "mechanics" constitute the largest class separately enumerated. The reason of there being so many mechanics employed is that most British railway companies build and repair their own locomotives and rolling stock, while a number also manufacture their own signalling apparatus, and one, at least—the London and North-Western—rolls its own rails, and undertakes nearly all the steel and iron work for its bridges, warehouses, etc. Therefore, our railway companies are manufacturers in a large way of business. A large proportion of the mechanics employed in the erecting shops are paid pro ratâ a daily wage.

The "daily wages" staff also comprises a number of "supernumeraries." For example, at Christmas time, additional hands have to be

engaged as passenger porters. Further, railway companies give limited employment to females. Till quite recently, female employees were confined to such posts as laundry-maids, ladies' cloak-room attendants, and barmaids in refreshment rooms. However, female clerks are now employed by the principal railway companies in the chief goods offices, and the employment of women in this branch will be augmented in the future. The Great Western Railway employs female attendants on a few of its long-distance corridor expresses. The duties of these "train maids" are the care of the toilet-rooms, the charge of children while their parents or guardians are at meals in the restaurant cars, and the chaperonage of ladies travelling without an escort. The Irish railways have some female booking clerks. It may be noted that the Continental railways go further than the British where female labour is concerned, employing women as gatekeepers at level crossings, and placing them in charge of signal cabins on main lines even. On its present comparatively small scale in the goods and traffic departments, female labour is mainly recruited by selection from among the daughters of the companies' "weekly wages" staffs.

Premium Apprentices. Most companies take "gentlemen," "cadet," or "superior apprentices" into their locomotive and engineering departments, and one or two also admit a few such premium apprentices to the clerical staff. The age at which "superior apprentices" are accepted is generally about 17 years. There is no formal examination save for sound health and eyesight, but candidates are expected to have what is known as "a good public school education." The premium payable varies with the different companies from £50 to £100, and is partly returned in wages after a probationary period has been served, the remainder of the money being devoted to the mechanics' institutes, libraries, schools, etc., organised by the companies for the benefit of their employees. Premium apprentices go through the mill in the locomotive works, carriage shops, running sheds, drawing offices, etc., just like the sons of working men and clerks who are apprenticed to a railway company without paying any premium. As a rule, no definite promise of future employment when the apprentice shall have completed his training is made. There are so few higher posts in the railway service that the companies are flooded with fully-trained gentlemen apprentices, who do not care to accept all that their employers have usually to offer them—namely, subordinate posts worth £2 per week. Consequently, the majority have to leave home railway employment and try to obtain work on Colonial railways, or in various engineering industries. The fact that a young engineer has passed with credit through the Swindon or Crewe railway works is a good recommendation, although it is not a guarantee to his finding lucrative employment in civil life.

Railway Rules. Every servant of a railway company on his appointment is given a copy of the "Rules and Regulations," which have been agreed to generally by the companies that are parties to the railway clearing system. The manual contains a compendium of the rules laid down for signalling, control and working of stations, working of trains and permanent way and works. "Every servant will be held responsible for a knowledge of, and compliance with, the whole of its contents."

Varieties of Occupation. The railway service embraces several hundreds of distinct occupations and grades of particular occupations. The following table sets forth the principal callings of railway servants as distinct from the salaried staff. The department under which each occupation falls is indicated in brackets.

Artisans (engineer's)
Ballast packers (engineer's)
Bar boys (loco.)
Boiler smiths (loco.)
Boiler washers (loco.)
Book carriers (goods)
Brakesmen (goods)
Callers-off (goods)
Canvassers (goods)
Canvassers, passenger (traffic)
Capstanmen (goods)
Carriage cleaners (carriage and waggon)
Carriage examiners (carriage and waggon)
Checkers (goods)
Clerks, booking (traffic)
Clerks, goods (goods)
Clerks, parcels (traffic)
Clerks, lost property (traffic)
Clerks, telegraph (engineer's)
Clerks, female (goods)
Conductors (traffic)
Cooks, dining-car (hotels and refreshments)
Detective inspectors (general manager's)
Detective sergeants (general manager's)
Dining-car attendants (hotels and refreshment)
Electricians (electrical engineer's)
Engine-drivers (loco.)
Engine-coalers (loco.)
Engine-cleaners (loco.)
Firemen (loco.)
Fire-droppers (loco.)
Fire-lighters (loco.)
Fitters (loco.)
Foremen, platform (traffic)
Foremen, parcels (traffic)
Foremen, permanent way (engineer's)
Foremen, shed (loco.)
Foremen, shunter (traffic)
Gangers (engineer's)
Gatekeepers (traffic)
Goods agents
Guards, passenger (traffic)
Guards, goods (traffic)
Guards, relief (traffic)
Guards, porter (traffic)
Guards, pilot (traffic)
Greasers (carriage and waggon)
Horsekeepers (horse)
Horse stablers (horse)
Inspectors, district (traffic)
Inspectors, district engineer's)
Inspectors, platform (traffic)
Inspectors, yard (goods)
Kitchen porters, dining-car (hotels and refreshment)
Labourers, miscellaneous
Lampmen (traffic)
Letter sorters (traffic)
Loaders (goods)
Number takers (goods)
Omnibus drivers (horse)
Platelayers (engineer's)
Porters, platform (traffic)
Porters, luggage (traffic)
Porters, goods, indoors (goods)
Porters (parcels post traffic)
Porters, signal (traffic-signal engineer)
Point cleaners (engineer's)
Policemen (traffic)
Rail motor-car drivers (loco.)
Rail motor-car firemen (loco.)
Rail motor-car conductors (traffic)
Road motor-car drivers (loco. or special automobile dept.)
Road motor-car conductors (traffic)
Sand driers (loco.)
Searchers (goods)
Shunters, passenger (traffic)
Shunters, goods (traffic)
Signalmen (traffic-signal engineer)
Signal fitters (traffic-signal engineer)
Signal linemen (traffic-signal engineer)
Sleeping-car attendants (traffic)
Stationmasters (traffic)
Smiths, miscellaneous (engineer's, works manager's, chief mechanical engineer's)
Surfacemen (engineer's)
Telegraphists (traffic)
Telegraph messengers, juniors (traffic)
Telegraph linesmen (electrical engineer or signal engineer)
Ticket collectors (traffic)
Ticket inspectors (traffic)
Truck markers (goods)
Tube cleaners (loco.)
Van boys (traffic)
Van drivers (traffic)
Van mechanics (carriage and waggon)
Van washers (horse)
Waggon examiners (carriage and waggon)
Waiting-room attendants (traffic)
Watchmen (traffic)
Wheel tappers (loco. carriage and waggon)
Yardmen (goods)

Some particulars as to wages are included in the following articles of the series, which deal with the work of the different departments.

The companies also provide the uniforms for all members of the uniformed staff, and also certain articles of the working clothes worn by other servants. For instance, enginemen are supplied with pilot-coats and labourers with greatcoats. Then,

lodging allowances are given and travelling expenses defrayed when men are away from home.

Advantages and Drawbacks of the Service. The advantages and disadvantages of the railway service may be enumerated.

First is permanency of employment and security of pay. Once on the regular staff a man may rely upon continuing in the company's service till incapacitated by age, provided that his habits are steady and diligent. The railway service is on a par with the Post Office and other Government spheres of employment in that its employees have nothing to fear from fluctuation of trade. The only exception is the case of the mechanics employed at railway works, who are liable to be placed on short time, but not discharged in time of slackness.

Secondly, there are the liberal superannuation, pension, provident funds, etc., backed up by well-organised benevolent societies and saving banks.

Thirdly, the man has a fair field and no favour in respect to promotion. Sir George Findlay did not exaggerate when he wrote: "The humblest railway servant, if he does not, like one of Napoleon's corporals, carry a marshal's baton in his knapsack, may at least contemplate a field of possible promotion of almost as wide a scope." It would surprise the public to hear of the humble beginnings of many of the foremost railway men of the day.

First among the disadvantages are the long hours, and secondly, where the salaried staff are concerned, the emolument cannot be described as princely. The higher posts carry with them good incomes, but the number of such posts is proportionately very small, working out to about only one-tenth per cent. of the total number of all grades employed. Thirdly, hard and unremitting application to work is demanded of all railway men. There is a fourth disadvantage, which concerns only the operating staff—that is, enginemen, shunters, guards, etc., whose duties must be placed in the category of dangerous employments.

Superannuation. Superannuation fund associations are for the benefit only of the salaried officers, and membership is obligatory as a condition of service for all who join under 28 years of age. Their object is to provide each contributing member with a superannuation allowance on his retirement from the service between 60 and 65 years of age, or at any earlier period should his health permanently fail, provided that he has been at the time of his retirement a paying member for ten years, while there is also a payment to a member's next-of-kin in the event of his death before superannuation.

Each of the larger companies has its own superannuation fund, managed by its own officers, while the Railway Clearing House has—or, rather, had—a Superannuation Fund Corporation for all less important companies who chose to join it. In 1905, unfortunately, on a valuation the latter fund was found to be not what is called "actuarially sound," and the scale of benefits had to undergo drastic revision. The Great Central Company, however, withdrew and founded one of their own. They did it on terms amicably arranged and some of the other companies affected are now seeking powers to follow their example.

The members' contributions amount, as a rule, to 2½ per cent. per annum of their salaries, being deducted monthly from their pay, and the company contributes in equal proportion. If a member elect to retire from the service of a company before superannuation, or if his services be dispensed with by the company from any cause other than fraud or dishonesty, he receives back the whole of his own contributions. If he be dismissed for fraud or dishonesty, he is liable to forfeit the whole of his contributions. If he die before superannuation, his representatives receive the equivalent of half a year's average salary, calculated over the whole term of his contributions, or the sum of his own contributions and those of the company in his behalf, whichever be the greater.

Provident Societies. The "wages" staff, both weekly and daily, have the benefits of insurance, provident, and pension societies. The object of the insurance society is to provide an allowance for the first two weeks of disablement arising from accident incurred while in the discharge of duty, and a supplemental allowance to that provided by the Workmen's Compensation Act, 1897, in cases of disablement extending beyond two weeks, and an allowance in cases of death or permanent disablement arising from accident in the discharge of duty, in those cases in which the company are not liable under the above Act, or are only liable up to a sum of £10; also an allowance in cases of death arising from other causes than accident on duty. Membership of the insurance society is voluntary, the men contributing from 1d. to 3d. per week, according to class.

The provident and pension societies are usually merged together, and membership of both is obligatory.

The provident society insures a weekly allowance in cases of temporary disablement for work arising from other causes than accident on duty; a retiring gratuity for old or disabled members in certain cases, with the same restriction as before; a death allowance to the representatives of deceased members, provided that death was not incurred through an accident on duty; and an allowance towards the funeral expenses on the death of a member's wife.

The pension fund awards pensions to old or disabled members aged between sixty and sixty-five, subject to their having been members for a period of twenty years; while when he has arrived at sixty-five any member can claim his pension irrespective of the state of his health.

The weekly premiums to the joint societies begin at 2d. for third-class members under 18 years of age, or receiving less than 12s. per week in wages, and rise to 1s. 2d. in the case of members who join the first-class from forty to forty-four years of age.

Some companies have distinct benefit societies for the locomotive staff.

Continued

Group 10

TELEGRAPHS

1

Following on ELECTRICITY from page 4248

TELEGRAPHY

The Training of a Telegraphist. The Morse Code. The Transmitting and Recording Instruments and their Manipulation

By D. H. KENNEDY

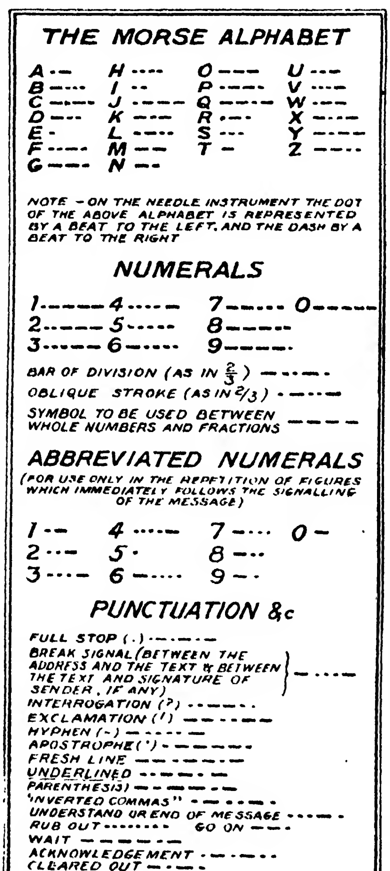
A PRACTICAL telegraphist is a person of either sex who has been trained in the art of signalling messages by electric telegraph. The length and variety of this training vary enormously, for whereas a few days' practice is often sufficient to enable the village shopkeeper to signal messages on the "Wheatstone A B C" instrument, years of training are required for the making of the all-round expert who can deal with all classes of instruments and of work such as are found in every large telegraph station.

Although the art of signalling messages was known before the invention of the electric telegraph in 1837, the enormous development which followed that epoch-making event necessitated the provision of large numbers of signallers, and opened a new career to many thousands of both sexes. In passing, we may mention that there are numerous instances of telegraphists attaining to positions of world-wide fame, noteworthy examples being Edison, the great inventor, and Carnegie, the millionaire donor of libraries.

Entering the Service. The aspirant must first enter for one of the open Competitive Examinations for Telegraph Learners. Full information is given in the Civil Service course [page 2807], and we shall assume that his visit to the Civil Service Examiners has had a satisfactory result, and that he has also passed safely through the inspection of the medical officer.

Our learner now takes up duty in the Telegraph School at the G.P.O., where he will remain until he attains sufficient expertness to deal with public messages. He will receive no pay, will practise eight hours per day, and may require from 10 to 20 weeks to reach the required standard. In most cases the learner will, on entering the school, see for the first time a telegraph instrument, but many energetic youths while preparing for their Civil Service Examination obtain also tuition in practical telegraphy at outside schools, such as that conducted at Mortimer Street, London, by the Regent Street Polytechnic. The length of time without pay is reduced accordingly.

The learner's first duty is to make acquaintance with the Morse code [1] and the time code [2], and for this purpose he is provided with cards giving the necessary information.



1. MORSE CODE

It will be seen that the letters of the alphabet are formed by combinations of dots and dashes, varying in number from one to four, while the figures in each case have five. In determining the proportionate length of the various signals and spaces, the fundamental unit is the dot. A dash is equal in duration to three dots. The space between the elements of a letter is equal in length to one dot. The space separating the letters of a word is equal to three dots, while the space between words is equal to six dots.

The time code is used principally to indicate the time at which a telegram was handed in. Each figure on the clock has an assigned letter, so that A stands for 1 o'clock, C for 3 o'clock, AC for 1.15, CA for 3.5, and so on. For the four minutes which intervene between every two five-minute points, the letters r, s, w, and x are used, so that CAr means 3.6, and ACw means 1.18.

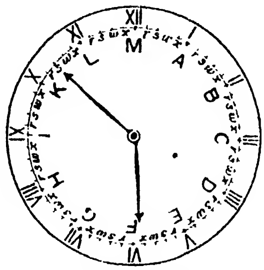
The Sounder Instrument. After studying this card the learner will take his place at a sounder set [5], consisting of a single-current key and a sounder. They are *short-circuited*—that is, arranged so that the key controls the sounder. There he will spend many hours practising the formation of the letters, and familiarising his ear with the sounder.

Much care and patience are necessary, for a bad style once formed cannot easily be improved. C is usually found to be the most difficult letter, while H and V also require special

attention. When he has made some progress the learner is allowed access to the inkwriter [3]. Here, in addition to hearing the sounds, he has a printed record of his efforts, and is able to see from the inked slip which letters require most attention with a view to improvement.

Before introducing any other instrument, it will be well to explain the adjustments of those already mentioned. Further details of the theory and construction of all the apparatus will be found in Telegraph Engineering. The telegraphist is concerned only with the working adjustments.

Adjusting the Key. The single-current key is made up of a brass lever which is mounted on an axle so that it oscillates between two contact points. At the front upper side of the lever there is a horn or ebonite knob which is shaped so as to be conveniently held by the thumb and first two fingers of the right hand. The brass bridge and contact points are fixed on a suitable wooden base. Normally the lever is held in connection with the rear contact point by the tension of the spiral spring.



2. TIME CODE

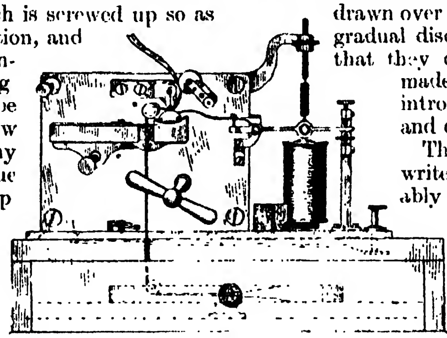
There are only two adjustments, one to determine the amplitude of the oscillation—commonly called the *play* of the lever—and the second to regulate the tension of the spiral spring. The former adjustment is made by means of the long screw which passes through the rear end of the brass lever. The screw has a cylindrical head containing small holes, so that it can be turned by a capstan spike, a little tool better known to the telegraphist as a *tommy*. It will be observed, however, that the end of the brass lever is split, and on one side of the lever there is a blue metal screw which is screwed up so as to tighten up the split portion, and prevent the adjustable contact screw from moving. The blue screw must first be opened; the contact screw can then be altered to any desired position, and the blue screw again tightened up. The usual amplitude is about $\frac{1}{32}$nd of an inch. The adjustment of the tension is made by raising or lowering the screw nearest the axle. For this purpose a screwdriver is necessary. Oil is never necessary, and it should be remembered that oil is an insulator, and that its presence on electrical apparatus usually leads to trouble.

Adjusting the Sounder. We turn now to the sounder. It is a little more complicated than the key. It consists of an electromagnet and a movable armature. The electromagnet—two bobbins of insulated wire, having iron cores connected at the lower end by a yoke piece of iron—is fixed to the brass base. The armature—a piece of blue annealed soft iron—is fixed by a screw to a bent lever of brass, the latter being provided with axle pins, and mounted in a brass bridge.

The bottom end of the armature lever is attached to a spiral spring. The other end of this spring is connected to the milled adjusting screw which can be seen in front of the cores, and normally the spring tends to hold the armature away from the electromagnet.

The upper end of the armature lever carries an adjustable stop which passes through it, and strikes against the angular bridge piece, when the armature is attracted. The uppermost adjusting screw forms the banking stop for the lever in its normal or upper position. Both of these adjusting stops, and the two axle screws are provided with check nuts. In adjusting a sounder it is first necessary to see that the lever is properly centred, and the axle screws neither too tight nor too loose. The lower adjusting stop should then be fixed so that the distance between the armature, when depressed, and the iron cores is about $\frac{1}{100}$th of an inch. It must be specially noted that if the armature be allowed to touch the cores it will not work properly. The upper stop should next be adjusted, and, finally, the tension of the spiral spring.

Adjusting the Inkwriter. The *inkwriter* [3], now but little used in comparison with the large number of sounders, was, in this country, the predecessor of that instrument. It is practically the same instrument, but with the armature lever lengthened to carry an ink-wheel rotating in an ink-well and arranged so that when the armature is attracted the wheel makes a record on a paper tape which is drawn over a roller by clockwork. The gradual discovery by expert operators, that they could interpret the sounds made by the armature, led to the introduction of the much simpler and cheaper sounder instrument.

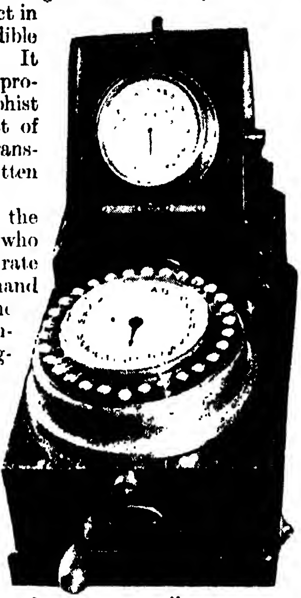


3. INKWRITER

The adjustment of the inkwriter, however, differs considerably in detail from that of the sounder. The end in view is the same in each case, but whereas with the sounder we begin from the fixed electromagnet and bring the other parts into proper relation, in the case of the inkwriter we have to begin with the ink-wheel, which must first be properly arranged for marking the paper when the armature is attracted. This is achieved by regulating the bottom banking stop of the armature lever. The upper stop limiting the play next receives attention, and finally the electromagnet is brought up to the proper distance from the armature by turning the adjusting screw near the base of the electromagnet. The tension of the antagonistic spring is adjusted in the same way as for the sounder.

Acquiring the Art. Generally speaking, the learner progresses in "sending" much more rapidly than in "receiving." A large amount of practice is needed to enable the ear to recognise rapidly each combination of signals, and for the brain and the hand to act in unison, and so to translate the audible signals into the written message. It will be observed that the mental process in which the receiving telegraphist is engaged is very similar to that of the shorthand reporter—each is transforming audible sounds into written symbols.

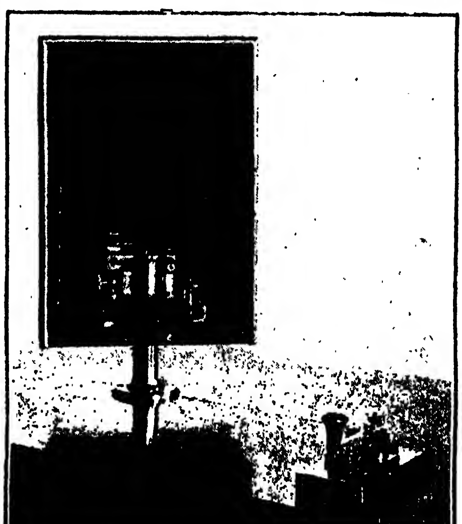
In each case the writer is at the mercy of some other individual, who sets the pace. Fortunately, the rate at which it is possible to send by hand on a telegraph key is about the same as that which can be maintained by an expert writer of longhand. The average rate maintained by good operators is about 25 words (125 letters) per minute. In occasional cases, the rate goes up above 30 words per minute, and may reach 35, and in extraordinary cases 40 words per minute. Learners usually find the greatest difficulty at the stage from 15 to 20 words per minute. Not only have they at this point to mend their pace in the matter of writing, but at this speed it is quite impossible to set down letter by letter as received, and difficulty is experienced in following up because the writing is necessarily some way in arrear of the signalling. All these difficulties, however, give way before application and perseverance, and it is marvellous how expert the telegraphist ultimately becomes.



4. THE "A B C" MACHINE

It is the special virtue of the sounder system that, as only the ear is employed in the reception of the signals, the eye and hands are left free for writing.

In order to lighten and diversify his labours, the learner is also introduced to the A B C needle and punching instruments at an early stage, and thenceforward a certain amount of practice is had on each daily, the sounder receiving the greater share.



5. THE SOUNDER INSTRUMENT

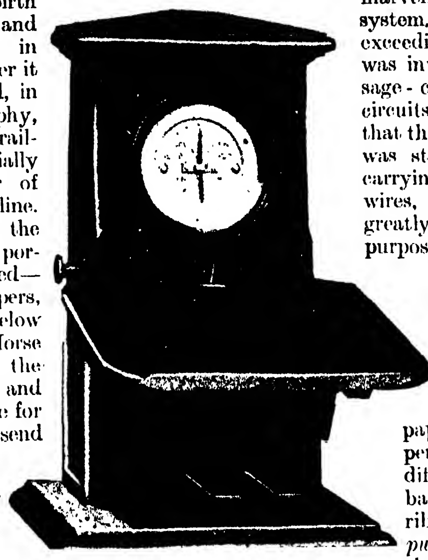
A B C System. But little need be said of the A B C [4]. This instrument was one of the many ingenious inventions of Sir Charles Wheatstone. The method of operating is simplicity itself. Each station consists of two instruments the communicator and the indicator. The latter stands upon the rear portion of the first-named. The communicator dial is surrounded by 30 keys. The rearmost key is marked + (sometimes called zero), then follow the letters A to Z, and the three punctuation marks (, ;.). On an inner circle the numerals appear twice, once from A to J, and again from P to Y. The indicator dial is marked in the same way. Normally, both pointers stand at the zero +. In order to send, the little crank in the front side of the communicator is turned at a uniform and fairly quick rate, and the letter keys are depressed one after another in the order required to make up any given word. The depression of each key automatically raises the key which had last been depressed, and the communicator pointer follows round. The end of each word is indicated by depressing the zero + key. If any figures occur, the telegraphist signals ";". The signals which succeed this are read from figures on the inner circle, and the finish of the group of figures is also indicated by the signal ";".

In recent years, however, the Post Office has found it necessary to abandon the use of the dial numerals, and to substitute a system of spelling out figures, prefacing the group of figures by the signal FI, and following by the signal FF. As the communicator needle travels from point to point, the indicator needles, both at the home and the distant station, move in exact synchronism, and so the message can be read and set down letter by letter by the distant operator. Usually the receiving clerk acknowledges the receipt of each word by sending one revolution. When from any cause the needles get out of synchronism, the communicator needle must be turned to the zero, and the indicator needle brought to the same point by oscillating the little adjusting key which can be seen just below the dial. No other adjustment can be made without the aid of a lineman or mechanic. Any person of average intelligence can send and receive messages on this instrument after an hour or two's practice. The rate of working is, however, always very slow. Ten words per minute is a good average

speed, 20 is quite exceptional. Its use is now practically restricted to village offices where messages are so infrequent as to render the retention of a skilled operator unremunerative.

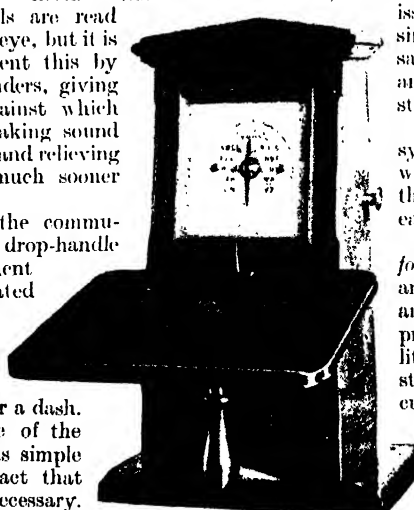
The Single Needle. The single needle [6], invented at the very birth of telegraphy, still survives, and possesses features which, in special circumstances, render it very valuable. In England, in addition to postal telegraphy, it is very largely used by railway companies. It is specially suitable where a number of stations are grouped on one line.

In the Post Office form, the *commutator*—as the sending portion of the instrument is called—consists of two keys or tappers, which project forward below the writing desk. The Morse code is used, modified to the extent of substituting right and left deflections of the needle for dashes and dots. Thus, to send the letter A, the left key is depressed, followed immediately by a depression of the right key. Simultaneously the needles at all stations will deflect first to the left stop, and then to the right. The spacing between letters and words is similar to sounder working; but as the time required for the "dash" element of a signal is the same as for the "dot," it is possible to send at a higher rate on the "needle" than on the "sounder." The signals are read from the needle by the eye, but it is now usual to supplement this by providing two tin sounders, giving out different notes against which the needle beats, so making sound reading quite possible, and relieving the eye, which tires much sooner than the ear.



6. SINGLE-NEEDLE TAPPER FORM

For railway service the commutator is usually of the drop-handle form [7]. The instrument can then be manipulated by one hand. The handle has three positions—centre or normal, to the right for a dot, and to the left for a dash. One special advantage of the single needle, due to its simple construction, is the fact that adjustment is rarely necessary. It is sometimes, though only rarely, affected by earth currents, which give the needle a bias to one side or the other. To meet such emergencies the dial is arranged so that it can be rotated through a large arc of a circle. It is accordingly turned round until the needle is properly centred between the stops, when working can be resumed. What may be called the workshop adjustments of the single needle will be dealt with in the Engineering section.



7. SINGLE-NEEDLE DROP-HANDLE FORM

High - speed Telegraphy. Having earned his spurs at the various manual systems, our learner will be allowed to approach the marvellous Wheatstone automatic system. When wires were few and exceedingly expensive, this system was invented to increase the message-carrying capacity of long circuits. Wheatstone early realised that the quickest manual signalling was still a long way below the carrying capacity of telegraph wires, and he sought a means of greatly increasing it. For this purpose he designed three instruments—the perforator, the automatic transmitter, and the Wheatstone receiver.

By means of the *perforator* [8], messages are transferred to a long thin paper ribbon. Of course, several perforators may be used by different operators preparing a batch of messages. The paper ribbons, commonly called *punched slips* [9], are passed through the automatic transmitter. Controlled by the slips, the transmitter sends signals exactly similar to the human operator, but with the accuracy proverbial of a machine, and at speeds up to 600 words per minute. At the distant station the messages are received on a blue ribbon, which issues from the receiver in a fashion similar to the printer, but with the same difference as to accuracy and speed as prevail at the sending station.

One sees at a glance that this system deals with messages on the wholesale principle, and enables the labours of several operators at each end to be applied to one wire.

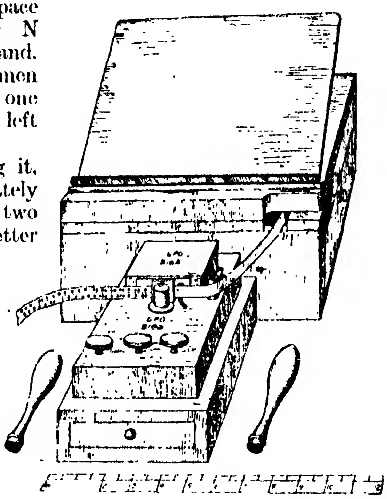
The Perforator. The *perforator* [8] is a little mechanical arrangement in which three keys are arranged so that when depressed by striking them with little rubber-shod iron punching-sticks, they operate levers and cutters which make certain holes in a white paper ribbon. The left key corresponds to dots, the centre key is the spacing key, and the right key makes the dashes.

In the operation of punching both hands are used, but the keys corresponding to the required dots, dashes, and spaces must be struck in proper order, and under no circumstances simultaneously. After punching the dots and dashes to form a letter, the centre key is depressed once, before commencing the next letter, and

after the last letter of a word, the space key is struck twice. Here, again, a good beginning is valuable. The badly-taught "puncher" does all the spacing with his right hand, and gets along very slowly in comparison with the man whose style has been formed on right lines.

The golden rule for punching is—space with the hand not required for the last stroke of each letter. Thus, after A (·—), space with the left hand; after N (—·) space with the right hand. The word shown on the specimen below [9] is a favourite one for practising right and left spacing,

Punching. In punching it, the hands come down alternately throughout, except where the two dots come together in the letter "d." Very good punchers carry the alternating use of both hands a stage further by using them on one key for the letters "H" and "O." The average rate which a good "puncher" can maintain is about 25 words per minute. The work is not unpleasant, and good operators usually consider it a pleasant change from their other duties. At the receiving end the slip comes from the receiver marked in the dash-and-dot style, which our learner has already met in the inkwriter. Daily practice in writing up slips will complete his round of school duties. The beginning of the slip to be transcribed is held in the left hand. The next foot or so is laid flat on the desk between the left hand and a "slip conductor," a sort of paperweight with a little upright pillar. The remainder of the slip usually extends to the floor. By the aid of the thumb and first finger of the left hand, the slip is pulled along as quickly as the eyes can read and the hand write. Twenty-five to 30 words per minute is the usual average rate.



8. PERFORATOR

Telegraph Instrument Room. What becomes of our learner when he has been judged ready for practical work will depend on the varying needs of the service. If the demand for telegraphists is great, he may be put on practical work at once; if not, he will probably be employed half-time on telegraphy practice, and half-time collecting—that is, carrying message forms from point to point in the instrument room.

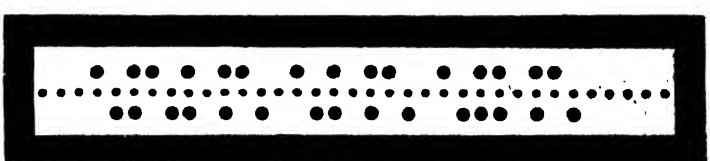
As being the best case to enable us to take a bird's-eye view, we shall suppose that we follow him into a large provincial office. On the door of the instrument room is a notice warning all and sundry that the room is strictly private, and can be entered only by those having the permission of the secretary of the Post Office. Our fledgling telegraphist, remembering that he has already appeared before a magistrate and taken the oath of secrecy, presses forward with only a slight hesitation.

It is the middle of the morning, and immediately our ears are assailed by such a buzzing and clicking and humming that we at once think of a beehive. Across the room run long, narrow tables crowded with apparatus. Sitting at one side only, and all facing towards the centre of the room, we see rows and rows of men and women operators. Many youths are hurriedly carrying messages from point to point. Older men are dotted about the room, evidently each in charge of two or three tables, while near the middle of one long wall we see a sort of pulpit-desk, where sits the presiding bee, keeping watchful eyes on his many workers. In a telegraph office there are no drones.

The Test Box. Opposite the pulpit, on the other long wall, our eyes are entrapped by a projecting wall of dark, polished wood, about 20 ft. long and 7 ft. high, with a yard-wide frieze of brass screws along the eye line and a square check pattern, still in brass screws, further down. This is the *test box*, where all the lines from distant towns and from the sets of apparatus in the instrument room are concentrated, each on its proper brass screw, numbered and labelled.

Further along the same wall, made conspicuous by some hundreds of small pigeon-holes, each containing quantities of the familiar buff envelopes, is the delivery department, where young ladies are engaged in enveloping telegrams.

The man to whom a telegram rarely comes learns with surprise that in every large town there are firms whose daily average of telegrams runs into two, and sometimes three figures. For such folk the Post Office finds it economical to have supplies of envelopes with printed addresses, hence the many pigeon-holes. Here one also notices the ingenious little machines employed for numbering the messages.



C A N A D A

9. PERFORATED SLIP WITH PERFORATIONS FOR THE WORD "CANADA."

Continued

REST, SLEEP, AND EXERCISE

The Proper Place of Athletics. Their Danger and Abuse. Exercise and Health. The Value of Rest to Young and Old. Holidays

Continued from page 4258

By Dr. A. T. SCHOFIELD

IT is the undoubted duty of every man to see that, as far as possible, his body is in a sound condition; and it is beginning to be recognised that not only is one's own health imperilled by neglect, but that a stunted physique may result in a degenerate offspring. Athletics rightly pursued, or their equivalent in exercise, become, therefore, a duty, binding in various measures on every man, woman, and child.

Exercise and Physique. In the manufacturing districts, the general physique had so degenerated a few years ago that the average stature of a man was but 5 ft. 1½ in., and his weight 106 lb.; whereas, in certain northern counties, in country districts, where bodily exercise was the rule, the men averaged 5 ft. 11 in., and weighed 199 lb. Possibly other circumstances favoured the difference. We may be sure, however, it did not end with the physique, but affected every part of the mortal being.

The development of athletics is of recent date. Thirty or forty years ago our daily papers took no notice of any sport but horse-racing, which can hardly be included under athletics; there were no crowds at boat-races, or at Lord's. Though it seems strange to say so, it is only an insignificant minority that actually engage in outdoor games; and, so far from their being overdone, the pressing need of the day is still more and more outdoor exercise for our urban population. The outcry that has arisen against athletics is rather against the betting, the gossiping, the reporting and general puffing, than the actual playing.

"Sportsmen" who Never Play. We distinctly say now, in 1906, as Dr. Warre so well pointed out at the Health Congress in 1886, that the value of outdoor games is *not* yet understood. The interest in sports is great, but the players are few, and the value of the exercise is only experienced by those who play—not by those who look on. At Lord's, out of 2,375 members, only 118 played on the ground in one year. In all London there are not probably 4,000 football players out of the population of 800,000 men. Probably not more than 1 per cent. of men between twenty and forty play games at all, and still fewer young women, whose physique is of such national importance to our race. Their chests usually show conspicuous want of development of lung power, solely from lack of physical exercise. It is true that among a few of the rich the love of outdoor exercise is carried to excess, but these are small exceptions. On the other hand, the real importance, and indeed necessity, of physical culture is beginning to be more realised. In children especially it is becoming better understood, and they are getting straighter backs and broader chests. Attitudes in school hours are studied, and games and drills are fostered; so that while the general physique of the lower classes is still very poor, that of the educated classes is greatly improved. Indeed, we may say that a boy at Harrow or Eton will average 3 in. taller and a stone heavier than a boy of the same age in a London County Council school.

The Average Man's Exercise. Generally speaking, the muscular system is in good condition when the person is about his right weight, and takes plenty of exercise. Games, however valuable, have certain drawbacks in over-developing various parts of the body, which regular gymnastic exercise is always seeking to correct.

A remarkable instance of this is seen in the connection of lateral curvature of the spine with the attitude of writing. A very large proportion of these deformities are caused during school life by the twisted position of the body that was in vogue, especially in girls' schools, in the days of the old sloping, angular handwriting. Ambidexterity in school life, and afterwards in some professions and trades, tends to correct this. When the muscles of the limbs that meet the eye are kept in condition, we know that those muscles that we cannot see, and on which our life depends, such as the muscles of the heart and internal organs, are also strong. Exercise is therefore essential for health, and the amount required by the average human being has been roughly stated as a mile walk a day for every stone weight. In this is included *all* exercise taken, such as walking upstairs or about a room.

Exercise, the Beautifier. What exercise can do in the way of beauty has been so graphically described by Sir F. Treves that it may be quoted with its wealth of adjectives entire: "Physical exercise is capable of healthfully transforming the meaningless, monotonous, purposeless curves of the physically uneducated, who are mainly muscular paupers, whose limbs are little better than burlesques, composed as they are of shapeless masses of flabby, doughy tissue, covered with dull, loose, lustreless skin, into the beautiful, classical, muscular outline of ancient statuary, clothed with the polished, fresh, elastic skin of perfect health." Who would not take exercise after this?

Exercise varies with age and sex. In childhood, games and musical drill are best; in boyhood and youth, games and field sports and general athletics, always avoiding what leads to extreme exhaustion or breathlessness,

such as prolonged runs at "hare and hounds." We must remember, too, that these sports bring only health to the actual players, not to the mere onlookers. Riding, walking, rowing, and cycling are pre-eminently of value to all classes.

For girls and young women games and sports are good, omitting the most violent, such as football. They conduce to growth, beauty and health.

Looking on is not Athletics. Men of mature years depend on walking, riding, cycling, for exercise, with sometimes cricket—but never football—and often, and increasingly, golf. Of the physical value of golf for maturity and old age there can be no doubt; but we question very much whether its solitary nature and its absorbing character does not often develop unpleasing traits and tend to selfishness.

All through mature life, ten minutes' brisk exercise after the daily morning bath is good. At least two hours a day should be spent where possible in really active exercise.

A revolution has been going on and is still progressing in the medical profession with regard to exercise. More and more the natural therapeutics of exercise and rest, of fresh air and quiet, are coming to the front.

Exercise on some such lines is indispensable to health, and is far too little thought of amongst town-dwellers and sedentary workers. These are constantly getting out of sorts for want of sufficient brisk exercise. It is well if, at least once in the day, one glows all over with active exertion, so that the whole stream of life is quickened in every organ—and this can never be achieved by a lazy stroll or by watching a cricket match.

A rigid examination into the physical condition of our youth and manhood has shown a great lack of physical culture, and has dissipated the hollow fallacy that looking on at sports is "athletics." Watching games has largely taken the place of playing them, and it certainly saves labour; or, rather, it substitutes unhealthy brain excitement for healthy bodily exercise. The whole tendency is in this direction, and both motor-cars and motor cycles contribute directly to it. Nevertheless, we must not be pessimists, for, in spite of all, the race is evolving. The civilised portion, as judged by the size of old armour and the like, is said roughly to be increasing at the rate of 1¼ inches in height in every 1,000 years.

The Finest Exercise for Girls. Our girls have certainly benefited in stature and general physique by the increased attention to games and sports; and, after all, the body of the woman is of more value than that of the man. For the mothers of the race a fine physique is imperative. This Nature clearly teaches, for we see that in times of famine more boys are born than girls (in the siege of Paris almost all the births were boys), while in times of plenty girls predominate.

Lawn tennis is undoubtedly one of the greatest boons ever bestowed upon our girl population. What this one game means to the future of the race in England—especially if we could get it more widely extended amongst our sedentary population of work-girls, dressmakers, governesses, clerks, etc.—we can never know. There is no sight that speaks more for the future welfare of England than a group of well-made English girls returning from a tennis lawn, their every movement instinct with healthy life and vigour. It is in vain, therefore, to set against this a sprained arm or ankle, or even a strained heart, as occasionally may occur among the weak.

But the mental value of athletics is also very well marked and quite undeniable. This is perhaps largely due to their increasing social character in the present day. Social athletics and crowded pleasure grounds and matches are no doubt largely due to the increase of town populations and the facilities of travel. Hence, clubs and recreation grounds and parks with gymnasia, and cricket grounds are multiplied everywhere.

The playing of games together in friendly competition tends to develop self-control, firmness, manliness, unselfishness and general goodfellowship, while it lessens self-consciousness. It also develops nerve force, on the one hand, while it lessens nerve strain and nervousness, which is really nerve weakness, on the other. Athletics, rightly used, develop patience, perseverance, self-restraint, friendship and humility, and increased will power.

Dangers of Athletics. Lest, however, we should be accused of holding a brief for one side only, let us now consider what evils are connected with athletic exercise. These, like the advantages, are twofold—physical, and mental or moral. The former may arise from athletics directly or indirectly. Amongst the direct physical dangers are sprains and strains of the muscles, accidents to life and limb, and internal injuries.

Sprains and strains are very common, and arise from overtaxing one's power, as in severe competition; from pure accident; from want of training, and from excessive violence.

Accidents to life and limb are still more serious; and we fear, in spite of what its apologists may say in its favour, a grave case can be made out against football, and particularly when played by men's clubs according to Rugby rules.

From September, 1889, to the third week in January, 1890, the direct deaths from football were 13; the fractures of legs, 15; of arms, 4; of collar-bones, 11; and severe internal injuries, 7. A great deal might be made out of the fact that the mortality from football in three months is nearly double that of hydrophobia in England for three years, there being eight deaths from this cause in that period.

Internal strain and injuries may arise from over-exertion, or very commonly from want of training. Clergymen who go Alpine climbing in the autumn, and young schoolgirls who take exhausting cycling journeys, often suffer in this way. The heart, lungs, or any other organ may thus be severely injured.

Indirect dangers arise mainly from improper clothing or carelessness. The safe clothing for all athletics is flannel; and yet we see fashion requiring some of our public schools to play in linen shirts under a blazing sun.

Athletic Training. Turning to the moral evils of athletics, we are bound to say they are all excrescences, and that from athletics themselves, rightly conducted, no moral evil can ensue. The betting and gambling that disgrace so many of our grounds are beginning to be tabooed at some of those more recently opened, notably Paddington Recreation Ground. But there is great mental risk whenever men give themselves up to physical exercise and nothing else. This is especially seen in the case of prizefighters. Exclusive training of any one part of a man is necessarily very injurious to the rest. It is here, perhaps, in the devotion of every spare hour to physical exercise that to many young men the chief danger lies. There are other claims, associations that cannot be safely ignored. The most healthful life gives each duty its place, and looks for a wise proportion in all things.

The present system of training is the most healthy and natural imaginable. All the former fads of raw beefsteak diet and other absurdities have disappeared, and given place to a most sensible and regular mode of life. Without going into regular training, it would be well if those whose lives are sedentary, and who contemplate active exercise at any time or during the holidays, would make it a rule always to give themselves a little preliminary canter. For instance, in football, if a man is going to play who has not played for some time, it is astonishing what a help it is to take a little preliminary practice at kicking, stooping, running, and tumbling about.

No hard exercise should be taken without preparation. Before going to Switzerland the body should be hardened by prolonged walks and climbs at home. For want of this the holiday often does more harm than good.

Cycling, Walking, and Rowing. Cycling is such an admirable and delightful exercise that for hygienic reasons it is a great pity it has been invaded by the nerve-destroying motor cycle and the motor-car. Walking, after all, perhaps next to riding, remains the best all-round exercise, while rowing has a very special value in the form of sculling, and is especially good for young women, in that it gives the arms and chest and back free play while the rest of the body is still, and also because it is one of the few exercises that are not one-sided. Nearly all games use one side of the body at the expense of the other, hence the value of a few minutes' regular gymnastics each day to restore the balance.

It is important at all ages in exercise to stop short of exhaustion, such as, in the case of children, long walks, such games as hare and hounds, and paper-chases; in the case of young men, severe competitions. In old age excess is common—in running to catch trains, in over-cycling, etc., but moderation in all things is the golden rule, both in exercise and rest. 173.

In health exercise and rest go hand in hand; but of the two, perhaps, we can do better without exercise than without rest, though no one can really be well and strong who does not enjoy both.

Rest During Illness. In almost every accident and disease rest is not only an instinct but a necessity, and it is well to remember this. In the case of accidents, for instance, there is the general rest required after shock, severe internal injuries, and great operations. For all these rest in bed is the great resource. It is not too much to say that in such cases rest alone is worth more than all the other remedies put together. General rest, which is always best secured in bed, is required in fevers, which so rapidly exhaust the strength, in wasting diseases, especially consumption, in fits and faints, in painful diseases, such as rheumatism, heart disease, and all nervous breakdowns. These all are greatly relieved by simple rest and by the more elaborate "rest-cures."

It is most important to understand the value of local rest. If a man has broken his leg, it is not enough to put him to bed; local rest must be secured for the two fragments of bone, otherwise they will never knit. Nearly all cases of ununited fracture arise from want of complete local rest. Putting it in position is indeed all the doctor does when he sets the bone, for the splints and bandages are used simply so to fix the parts as to give them absolute rest. The same is the case with dislocation. The joint must be kept at perfect rest for some time, till the torn ligaments have united.

Bad sprains of any part of the body are cured by local rest. When an ankle is twisted, not only is the foot kept off the ground, but it is fixed on a splint. In all bad wounds and bruises, the part heals better and more rapidly if it is kept at rest; otherwise it will heal more slowly, or not at all. With inflamed joints, rest is the one thing needful. Knee or hip joint cases, which get little relief by the patient being put to bed, at once begin to improve when the inflamed part is absolutely at rest in proper splints.

"Local" Rest. Local rest is also required in all diseases of the internal organs. If there is an ulcer in the stomach, the only way to heal it is to give the stomach complete rest from food. If there are ulcers in the bowels, as in typhoid fever, the only way to heal them is to keep the patient at perfect rest in bed, and the bowels at rest by giving nothing but liquid food. In brain fever, the head is kept at rest by the avoidance of light, by the maintenance of quiet, by the use of a soft pillow, and, if necessary, by sedative medicines. When the pleura or covering of the lungs is inflamed, as in pleurisy, the pain is great each time the ribs move up and down in breathing. This is relieved by tightly strapping the ribs, so that they cannot move; thus the pleura gets rest. When the heart is diseased, although it cannot be put to rest entirely, its work is made as light as possible by the patient

lying in bed with the head low, and by perfect stillness. So we might go on through all the varieties of diseases, and show that in each and all of them the first great desideratum is rest.

If rest in illness is so important, rest after illness is hardly less so. The way in which men, after a severe and weakening illness suppose themselves strong because they are no longer ill, and at once resume work, shows how little this point is understood. Hardly less important than the hospitals are the convalescent homes, of which there are now some hundreds in England.

Rest in Health and Convalescence. In this case, however, the rest is only comparative, for the patient is no longer in bed, but strolls about in the sun and open air. It is difficult to lay down a general law as to the period of convalescence; perhaps the best that can be said on the subject is that only after very slight illnesses should work or study be immediately resumed, and that after all exhausting illnesses and fevers, a period of further rest should be allowed of not less than one fortnight, preferably more. In still more serious cases, when life has been in danger, the period of convalescence should equal the period of illness.

It is usual in all schools, and in most trades, to allow more time for meals than is absolutely required, this extra time being given for rest. It may be half an hour or an hour; whatever it is, it is of the greatest service, and those trades and professions are certainly injurious to health where it is not allowed.

Children at school may be allowed to play at this time, since it is their minds, not their bodies, that have been worked at school; but in the case of girls growing rapidly, or of weak health, it is far better to insist on their lying down during the spare time. For young children, the mid-day hour in bed is of immense value, and should be kept up till schooldays begin The mother's time for rest is generally in the afternoon, after the children have returned to school and the house is tidied up. An hour or two then on the couch, or better still, if possible, in the quiet bed-room, with the window open, gives her the rest she needs after the hard work of the morning, to brace her up for the remaining duties of the day.

How Long should we Sleep? There are some trades requiring night shifts, and occupations, like nursing, which reverse the natural order, and require the work at night and the rest by day. Such callings are never healthy, and sooner or later leave their mark. We must have night nurses and night watchmen, but it is well to know that the less night work there is, the better for health. For a short time of service, not exceeding three weeks, night work does not matter. When rest is taken in the day by a man working out of doors, as in ploughing, harvesting, and the like, we constantly find it spent in sleep, for there can be no doubt that nothing produces sleep better than hard work in the open air. Sleep, indeed, is always more enjoyed by body workers than by brain workers. The best rest after hard brain work is, not sleep, but exercise for the body, which acts as a rest or restorative to the mind.

With regard to rest at night in sleep, there are several points to be noted. The importance of sufficient sleep to any man cannot be overrated; when he gets it, he should rise in the morning with the strength and vigour of a veritable resurrection, the cares as well as the fatigues of the past day being gone, and the body well braced for the toils of another day. But what is sufficient sleep? The old adage, six hours for a man, seven for a woman, and eight for a fool, is very wrong. Eight for a man, nine for a woman, and ten for a child, would have been nearer the mark. Sleep must be not only sufficient, but refreshing. To ensure this, the principal ablutions with working women should take place at night. A right understanding of the extreme importance of health, of periods of relaxation, alone enables a hard-working woman to preserve her looks and spirits to a green old age. The right time for the father's ablutions is immediately on his return home at night, or, at any rate, after his evening meal.

When and How to Sleep. In close connection with the daily rest is the nap after meals. Many who are advancing in years resist this tendency by every means in their power, believing that it is a bad habit. On the contrary, it is a good one, though not needed by the young. The perfect rest it brings greatly favours digestion, and for the old it is really needed.

With regard to the rest at night, the bed-room should, if possible, be large and airy, and above the ground floor. Separate beds are healthier than double ones. They should be firm and comfortable, but not soft, preferably made with spring mattresses. The bed-clothes should be light and porous, but sufficiently thick to keep the person quite warm all night. The pillow should be soft, and high or low, as wished. But all these points are unimportant for giving perfect refreshing sleep compared with the question of sufficient fresh air. Unfortunately there still exists, generally without the slightest reason to support it, a singular prejudice against night air. Except in a few cases, where houses are built in low-lying grounds or marshes, or near rivers or canals, and in some exceptional cases of storm, wind, and rain, the window may be safely left open at night, for the air is then healthier and purer than in the day; and this is of the first importance to health while sleeping.

The Bed-room Windows. Out of one hundred parts of oxygen—the breath of life—which we absorb in the twenty-four hours to support existence, only one-third is taken in during the day, and two-thirds at night. No bed room ought, therefore, to be used by people in health that has not a direct communication with the open air. The top of the window should always be open, in summer as widely as possible, and in winter in such a way that a direct draught does not blow down upon the sleeper. The air should be directed upwards towards the ceiling by one of the many simple contrivances elsewhere described. [See pages 4019–4020.]

For children to sleep in pure air is, if possible, more essential still, and they should be thoroughly accustomed to sleeping with the window well open. It is only the habit of sleeping in close, stuffy rooms that renders a person liable to catch cold from an open window. Children should sleep on firm (not hard) beds, singly, if possible, with light but sufficient clothing. They should not sleep on the back or on the face. If a child persistently sleeps on its back, a towel should be tied in a knot in the middle and then fastened round the child's waist with the knot exactly on the spine; the child will never sleep on its back then. Children, especially when at school, require at night more fresh air than others do.

The Week-end. The custom of having no school for children on Saturday, and no work after two or three o'clock for men, is gaining ground everywhere, to the great advantage of the health of the rising generation. To children the boon is inestimable, and parents should make the most of it. The first point to remember is that as the child has been cooped up indoors all the week, therefore "out of doors" must be the rule on Saturday. This is the way to get the most good out of the day's rest. Children in town should spend the day in the nearest park, the country or the fields. Let no parent consider Saturday as a lost day to the child. If the other days are of importance for the child's mental development, Saturday is the day for the development and health of the body.

And what about men? How are they to get the most good out of their hard-earned half-holiday? Not certainly by spending it in some close room, but by taking that amount of relaxation that gives the most rest. Some are so hard-worked that a couple of hours' doze is essential before they are fresh and vigorous enough for a turn out of doors at all. Those engaged in much bodily labour should not undertake long and wearisome excursions on this day, but should remember that the watchword for the day is rest, and that this is the first consideration. Care should be taken, therefore, not to make a toil of a pleasure. Somehow it is usually the mother who gets least rest. To her is generally committed the task of looking after the children the livelong day, which, to her, is no change of occupation, and, therefore, anything but rest.

When the Body Rests. In all things connected with man, work and rest alternate at varying intervals. The very cells of the body are believed to have their time of rest. The heart itself rests four-fifths of every second; the lungs are at rest between each of the seventeen breaths that are drawn every minute, the stomach during the intervals between the digestion of the various meals, the brain between the intervals of study, the body at various periods during the day, partially, and completely at night when in bed. Some have cycles of work and rest, some complete in a single second, others in a minute, others in an hour or in a day, and others again in a week or even longer periods. The institution of the Sabbath, or one day of rest in seven is as old as man himself, and though it had to do primarily with the Ten Commandments, it is not necessarily kept from religious reasons alone, but also on hygienic grounds.

What Holidays Should Be. Most people, especially in towns, look forward to an annual break in the daily routine, by going away for a week or a fortnight, or a longer time, either to some seaside resort or to some country place. This practice is a good one, though it is often attended with drawbacks. Perhaps the railway journey is so long as to weary everyone both in going and coming; or the place is so crowded that there is no proper sleeping accommodation, and thus health is injured. The principle, however, when there are means to carry it out properly, is a good one, and infinitely better than that terrible rush some hundred or more miles on a bank holiday that is supposed to be "rest." When pleasure becomes hard work, and means rising at 5 a.m., and returning at 11 p.m., there cannot be much rest in it, or much health derived from it.

The rest obtained by living away from one's work in the country is somewhat dearly bought by the daily run to business; and when this means an hour by rail, the price is too high, for eventually the health is undermined.

With women who are overworked it may be remembered that twenty-four hours' rest in bed will often ward off an illness, and save a doctor's bill; and if the overwork is chronic, the mere fact of not coming down till after breakfast may make all the difference.

In old age, too, after 65, there should be a great increase of rest, and life should be taken more leisurely. Of course, the wisest maxims cannot always be obeyed, and necessity knows no law. Nevertheless, it is well to impress the therapeutic value of rest on all sections of the community, for not the least hard worked are the determined votaries of pleasure.

One point may be made in conclusion, that only those who work *can* rest; those who never exert themselves do not know the true meaning of the word.

NOTE. On page 3719 the table in the paragraph headed "Water Vapour" should read:

1 cub. ft.	of air	at 30°	Fahr.	can contain	2	grains	of water
1	,,	,,	40°	,,	,,	3	,,	,,
1	,,	,,	50°	,,	,,	4	,,	,,
1	,,	,,	60°	,,	,,	6	,,	,,
1	,,	,,	70°	,,	,,	8	,,	,,
1	,,	,,	80°	,,	,,	11	,,	,,
1	,,	,,	90°	,,	,,	15	,,	,,
1	,,	,,	100°	,,	,,	20	,,	,,

Continued

Group 2
ART
30
HISTORY OF ART continued from page 4302

ART IN MODERN TIMES

Gainsborough, Reynolds and Romney. Landseer and Wilkie. The Pre-Raphaelites. French Impressionism. Rodin, Meunier, and Stevens. The Art of To-day

By P. G. KONODY

Foreign Masters in England. At a time when Italy, Flanders, Spain, Germany, and France were witnessing the rise of great national schools of painting, England had to be content with deriving her art from foreign sources. Not that there was not an abundant supply of native talent from the days of Henry VIII. to the beginning of the eighteenth century, when Hogarth (A.D. 1697–1764) appeared on the threshold of a brilliant period of artistic activity, but the leaders around whom these painters gathered, and from whom they took their style, were of foreign blood and birth. Holbein was the first of the foreign masters who worked at the English Court and determined the manner of a whole generation of portraitists, especially of miniature painters, and Van Dyck, the Court painter of Charles I., may, with good reason, be called the father of English eighteenth century portraiture. His influence was enormous and lasting, though two other foreign masters stand between him and Gainsborough —the Germans, Sir Peter Lely and Sir Godfrey Kneller. Antonio Moro, Daniel Mytens, M. Mierevelt, Rigaud, La'gillière, and Canaletto all worked in England, and had their followers — capable artists like Dobson, Walker, and Samuel Scott, who have left us many works of merit without adding a single new page to the history of art.

90. THE SHRIMP GIRL, BY HOGARTH *Mansell*
(National Gallery, London)

William Hogarth. The first original word uttered by a British artist was spoken by Hogarth. Before him, painting in England had been altogether aristocratic and stately. His art was robust and healthy and democratic, almost plebeian. There is much of the English puritanical spirit in his scathing satires on the vices and weaknesses and immoralities of his contemporaries. He is, above all, a moralist —a preacher who uses his art as a weapon in the cause of virtue and righteousness. But these inartistic subjects are painted with consummate artistry. If the anecdotal painter generally fails, it is because a commentary is so often needed to make his work intelligible. Hogarth never supplies illustrations to other people's ideas, but tells his own stories with unmistakable directness in the language of paint. He conceives them as pictures, and, if one has eyes to see, one needs no explanation either of the story or of the moral to be drawn from such picture cycles as the "Mariage à la Mode," the "Rake's Progress," "The Idle Apprentice," and "The Industrious Apprentice." At the same time, Hogarth never allows his literary intention to interfere with the purely artistic consideration, never sacrifices beauty of arrangement and harmonious colour to the clearer telling of the story. The mastery of his brushwork can best be judged from a picture like the "Shrimp Girl" at the National Gallery, where the sheer beauty of paint can be enjoyed without the distraction of a moral sermon [90].

Gainsborough. The second half of the eighteenth century witnessed the rise of the great school of British portraiture, of which Gainsborough, Reynolds, and Raeburn are the brilliant luminaries. Of the two first-named, Gainsborough may be said to be the representative of the aristocratic and Reynolds of the democratic tradition. Gainsborough is, above all, the painter of the graceful elegance of contemporary society—his ladies are beautiful, distinguished, refined; his men slightly dandified; and his very technique, his deliciously cool colour schemes, and the negligent but sure elegance of his touch, reflect the character of his sitters.

Van Dyck is his real master, and his affinity with him appears clearly in such a picture as the famous "Blue Boy," which was painted in defiance of Sir Joshua's dictum that blue cannot be made the dominating colour of a successful scheme [91].

91. THE BLUE BOY, BY GAINSBOROUGH

Sir Joshua Reynolds. Reynolds, unlike Gainsborough, who had never left England or made a profound study of the old masters, had steeped himself in the art of the past and based his designs, his style, and his colour on the Italian masters. He was for ever proclaiming his allegiance to the "grand style," and his more ambitious compositions hold more than an echo of Tintoretto and Titian, of Correggio and Michelangelo, and even of Guercino and the later Bolognese. But not on these does his fame depend. With a curious perversity, which we find to an even greater degree in Romney, he set little store by his portraiture, which he considered mere drudgery, and pinned his faith to painting "histories" in the grand manner of the later Italian masters. With all their noble qualities of colour and design, they would to-day not suffice to secure Reynolds the eminent position he holds in the art of his country. This position is due to his powers as a portrait painter. And, as such, he is the antithesis of Gainsborough. He is as intellectual and searching as Gainsborough is elegant and superficial, and his sitters were not so much the society beauties of the day, but the aristocracy of intellect—men of letters, politicians, actors, philosophers, and scientists. In the place of the cool musical colour of Gainsborough applied in loose, thin touches, he prefers a hot, sumptuous scheme carried out with firmness and energy in a thick impasto. As likenesses, his portraits are far more convincing than those of his rival. He particularly excelled in portraying the innocent charm of childhood, and may, in fact, be said to be the first artist who painted children *as* children, and not as miniature men and women [92].

92. THE INFANT SAMUEL, BY REYNOLDS
(National Gallery, London)

George Romney. George Romney, whom fashion has placed beside these two masters, scarcely deserves to be held up as their compeer. His sense of beauty and technical skill were certainly second to none, but he fell into a mannered convention which, while searching for prettiness—and finding it—lost in character and sincerity. The vast number of portraits left by his brush might all have been painted from members of the same family. Raeburn (A.D. 1756-1823), the greatest master produced by Scotland, has, unlike Romney, met with comparative neglect, though he is now rapidly gaining the recognition which is his due as the father of the modern Scottish school, a daring colourist of rare strength and virility. As regards summary expressiveness and breadth of brushwork he is unapproached by any of his contemporaries. With broad sweeps of the brush he suggests all the subtleties of modelling and drawing. Hoppner, Opie and Cotes must be mentioned among the masters of these halcyon days of English portraiture, while Sir Thomas Lawrence connects these days with the period of academic sloth from which English painting was only liberated in the Forties by the Pre-Raphaelite revolt.

Landseer and Wilkie. Only landscape painting [see page 4299] made giant strides in this period, and Constable and Turner showed the way to the Barbizon men and the impressionists; while soapy and insipid portraiture, uninspired relating of anecdotes in paint, theatrical scenes of history, and such like held the public, and academic painting erred further and further in the path of bituminous gloom. Even where there was real talent, as in the case of the animal painter, Landseer, concessions had to be made to the public demand for humorous anecdote. David Wilkie must be mentioned among the great artists of that period, a real master in the handling of pigment which with

him retains an extraordinary richness of quality in spite of the minute precision of his detail. He was influenced chiefly by the Dutch small masters, and his skill in composing and arranging groups of figures and in massing the light and shade deserves the greatest admiration. William Blake, a mystic whose weird, fantastic imagination defied all laws of Nature, belongs to this time, but was an isolated appearance in the history of art.

93. LORENZO AND ISABELLA, BY SIR J. E. MILLAIS, BART., P.R.A.
(Walker Art Gallery, Liverpool

The Pre-Raphaelite Brotherhood. On the whole, English painting was at its lowest ebb in 1848, when a few ardent young spirits, led by D. G. Rossetti, J. E. Millais, and W. Holman Hunt, resolved to renounce the artificial academic formula of the day, and to follow the example of the Italian primitives, to approach Nature in a humble, naive spirit, and to do away with theatrical posing and bituminous shadows and ready-made recipes for making pictures. The famous picture, "Lux Mundi," is reproduced in colour opposite page 625, and another excellent example is the "Lorenzo and Isabella," by Millais [93]. Every detail, every grass blade or flower, stone or furrow, was made the object of careful study from Nature—so much so, that at times the larger truth was lost sight of in the passion for microscopic truths. As regards subject, romance and poetry were put in the place of the trivialities which then had the applause of the public.

The works of the Brotherhood aroused a storm of indignant abuse, but a powerful defender of their aims appeared in Ruskin, who threw himself heart and soul into the movement. The Brotherhood, as such, was short-lived, but the influence has been lasting, and is still to be felt in the art of to-day in spite of the growing supremacy of French ideas and techni

Art Under "The Empire." In France, which we have left at the threshold of the Revolution, more perhaps than in any other country, the political and social conditions are reflected by the currents of artistic evolution. The lascivious art of an immoral Court was followed by the chilling classicism of a Louis David, a true child of the Revolution, who, in his reconstructions of Ancient history, glorified the self-sacrificing patriotism of the Roman Republic, and then, as Court painter to Napoleon, became the originator of the Neo-Greek "Empire" style. With Napoleon's victorious campaigns arose an important school of battle painters, of which Gros and Gérard were the leading spirits. But neither art nor literature flourished during the first Empire, and only after the Restoration the intellectual life of France began to flow again in many contending currents. The first great battle was waged between Ingres, the head of the classicist school, who based his art on the imitation of the antique and perfect draughtsmanship, and Delacroix, the leader of the Romanticists, a truly inspired artist, with a glowing sense of colour and a powerful imagination. Then came the revolt of the Barbizon men, then the struggle of the freelight painters, and finally of the impressionists, whose aims have already been set forth in the article on "Landscape Art."

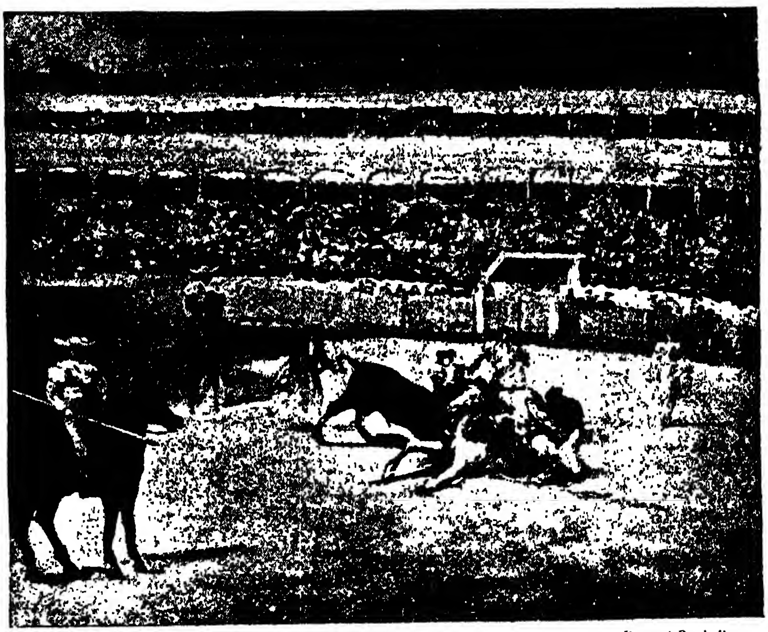
Impressionism in France. But impressionism has another aspect besides that of which Claude Monet is the chief exponent. As conceived by such masters as Manet and Degas, it substitutes beauty of character for beauty of form, and turns the attention of the artists to scenes of contemporary life. Classicism and academic art in general sail in lofty regions far removed from the bustle and strife of everyday life. The impressionists maintain, and frequently prove by their works, that the meanest subject is worthy of pictorial treatment if it is seen by the eye of an artist. As the word conveys, *impressionism* is concerned with the impression of a scene, which can only be recorded in its completeness by summary suppression of all the details which cannot be grasped at a rapid glance. The academic painter loses the freshness of an impression by using his *knowledge* of the form of things to penetrate the mysteries of distance or deep shadow. The impressionist loses outline and form where they are lost in Nature, and thus attains greater verisimilitude. The academic painter, in

treating the figure, loses the sense of movement through overcarefulness in drawing. The model is turned to stone, as it were, in the act of running, or wrestling, or dancing; while the impressionist, sometimes through accentuation, which is not, strictly speaking, correct, or through the effacing of contours, often succeeds in conveying an extraordinary suggestion of movement. Thus, in the ballet scenes by Degas, the dancers seem to be actually circling and pirouetting round the stage. As an example of Manet's work a reproduction is given of "A Bull Fight" [94].

Four Great Masters. Like the Pre-Raphaelites in England, the French impressionists had to fight a hard struggle before their views found acceptance, and there is no doubt that the extreme manifestations of impressionism frequently degenerate into absurdity and ugly caricature, and fully deserve the ridicule that has been heaped upon them. Yet it has remained one of the leading factors in modern art, not only in France but throughout Europe and America. Its influence has not always been beneficial, for the incompetent frequently sails under its flag to conceal lack of training and deficient draughtsmanship; but on the other hand, it has enriched the world with the masterpieces of a Monet, a Manet, a Degas, and a Whistler.

Nineteenth Century Art. In the rich artistic life of nineteenth century France, impressionism was only one, though the most important, phase. The academic school continued to flourish in the art of accomplished painters like Meissonier, Bouguereau, Delaroche, Fleury, and many others; the Orientalists, who found their subject-matter in the sumptuous picturesqueness of the East, are chiefly represented by Decamps, Fromentin, and Marilhat; decorative wall painting attracted masters like Puvis de Chavannes and, more recently, Besnard; Bastien-Lepage stands at the head of the freelight painters; while the most recent group, the intimists, include Le Sidaner, one of the most fascinating artists of the present time.

Rodin and Stevens. In sculpture, France took an uncontested lead during the nineteenth century. Rude (A.D. 1784-1855) was the first to return to the national tradition which the followers of Canova had forsaken for cold classicism. Barye (A.D. 1796-1875) stands unapproached as a sculptor of animals. Carpeaux, Frémiet, Dalou, and Falguière must all be reckoned among the masters of their art. They all went to Nature for their inspiration, instead of continuing the imitation of the antique that was so prevalent in the early part of the century. Rodin, finally, achieved the introduction of something like impressionism in sculpture. Of the masters of the past, Donatello is the one with whom he shows the greatest affinity, though Rodin's style is entirely original and personal. Through the accentuation and amplification of certain planes, he not only succeeds in suggesting movement, but a curious softening of the silhouettes, which makes his statues and groups appear as if they were bathed in atmosphere. Rodin, like all great reformers, met with bitter opposition, but to-day his pre-eminence in the field of sculpture is admitted by those who are most competent to judge. An example of his work is to be found on page 1675. In Belgium, Constantin Meunier has created, in stone and bronze, a mighty epos of Labour. His aims and achievements in sculpture are almost identical with Millet's in paint. The one great sculptor produced by England in the middle of last century was Alfred Stevens, whose Wellington Memorial in St. Paul's Cathedral is worthy to be placed beside the masterpieces of the sculptors of the Italian Renaissance. The last decades of the century witnessed an important advance in plastic art, and English sculptors of to-day have little to fear from comparison with their Continental contemporaries.



94. A BULL FIGHT, BY MANET

HISTORY OF ART *concluded; followed by* GLASS

Group 15 HISTORY 31 Continued from page 4322	MEDIÆVAL EUROPE Spain from Ferdinand II. to the Spanish Armada. The Netherlands' Struggle for Independence. Germany, Switzerland, and Hungary in the Middle Ages

By JUSTIN McCARTHY

SPAIN

We have already told how the Moorish dominion in Spain was brought to an end in the reign of Ferdinand II., and how Spain thus became, for the first time, one united sovereignty, and one nationality. Ferdinand married Isabella of Castile, which marriage helped effectually to bring about the union of the two kingdoms. Isabella was the sister of Henry IV. of Castile, and on his death most of the Castilian nobles refused to acknowledge the legitimacy of his daughter, Juana, and proclaimed Ferdinand and Isabella rulers of Castile. A civil war followed, in which Ferdinand was successful.

The reign of Ferdinand was remarkable for many events. He did much to restore peace and order to the country, and to diminish the power of the nobles. In his reign occurred the discovery of America by Christopher Columbus. There were many wars and civil struggles during his time, and throughout his reign he was ably assisted by the celebrated Cardinal Ximenes, who was, indeed, practically the ruler of Spain until the accession of Charles V.

The Inquisition. Ferdinand's reign has, however, left a dark memory behind it because of his establishment of the Inquisition and the cruel persecution of the Jews and of those Moorish inhabitants who had remained in Spain, led to remain there by conditions promised but never made good to them. Isabella died in 1504, and in the following year Ferdinand married a niece of Louis XII. of France. He ruled as regent for his daughter, Juana—who was insane—on the death of her husband, son of the King of the Netherlands, who died in 1506. Ferdinand died in 1516.

The destiny of Spain was for a time greatly influenced by the fact that Charles V., Emperor of Germany, succeeded to the Spanish crown. Charles inherited from his father, Philip, the Low Countries, Burgundy, and the Imperial throne; while from his mother, the daughter of Ferdinand and Isabella, he became heir to the rulership of Spain, Naples, and Spanish America. Charles, who was born in 1500, went to Spain in 1517 and was for a time joint ruler of the country with his mother, who afterwards became insane. In 1520 he was crowned Emperor of Germany, and soon after presided at the Diet of Worms, where Martin Luther's opinions were condemned, and in 1526 he married Isabella, sister of John III. of Portugal.

A great part of the European Continent soon became a scene for the display of the rivalry between Charles and Francis I. of France. Charles claimed the Duchy of Burgundy and that of Milan, while the King of France maintained that he was the sovereign of those regions.

The war at first was a success for Charles. He had the support of Henry VIII. of England, and also of the Constable Bourbon, one of the most powerful subjects of the French King. Charles drove the French out of Italy, and invaded Provence. Soon after, the King of France was defeated and taken prisoner, as already related in our French history. No sooner was this accomplished than the alliance which was called the Holy League was formed against Charles by Pope Clement VII, who had as his allies Henry VIII., King Francis, and the Venetians.

Imprisonment of the Pope. One event in the struggle which followed was that in 1527 an army of Italians, Spaniards, and Germans, led by Bourbon, entered and occupied Rome, and imprisoned the Pope. Bourbon himself was killed in the attack upon the city. Charles disclaimed all part in the movement against Rome, and repudiated any sympathy with the imprisonment of the Pope. A peace was finally made—the Peace of Cambrai—in 1529, by the operation of which Charles became practically the ruler of Italy. It was then that, for the first time, he went to see and study Italy for himself, and he was crowned at Bologna as Emperor of the Romans and King of Lombardy.

The struggles with France still went on, until in 1538 the new Pope, Paul III., the Sovereign of France, and Charles agreed to a truce for ten years. Among his other military and naval operations, Charles found time to head in person a maritime expedition against the celebrated corsair Barbarossa—the pirates of the North African ports were then an incessant trouble to southern Europe. He completely subdued Barbarossa, and captured Tunis. A later expedition of his against other Algerian pirates was less fortunate in its results, for the fleet which he conducted was brought to complete wreck by heavy storms.

The Triumph of the Protestants. The league which Charles had made with the Papal Government aroused the Protestants into armed resistance of his power, but the two campaigns which followed proved unfavourable to the arms of the Protestants, and a truce was agreed upon. But Charles's stern maintenance of the terms he had imposed, and the severity with which he treated his prisoners, among whom were the Elector of Saxony and the Landgrave of Hesse, turned many of his own supporters against him, all the more because it was now clear that his ambition was to become absolute ruler of Germany. Maurice of Saxony, a Protestant, who had up to this time supported Charles, now turned against him, and proved himself so well supported that Charles was compelled to recognise the Protestant claims, and treaties were made which ended in the Peace

of Augsburg in 1555. Charles was disappointed in some of his most cherished purposes by this and by other events, and he appears to have grown weary of rulership. He was breaking down in health, and suffering much pain, and in 1555 he resigned his position both as Emperor and as King, handing over the crown of Spain to his son Philip. He spent the remainder of his life in monastic seclusion at Yuste, where he died on September 21st, 1558.

Don John of Austria, who afterwards made himself famous by his wars against the Moors and against the Turks, was a natural son of Charles. In the great battle of Lepanto, October 7th, 1571, he conducted the combined fleets of Spain, Venice, Genoa, Malta, and Rome, defeated the whole arrayed naval power of the Turks near to Corinth, and put, for the time, a complete stop to the aggressive movements of Turkey.

Philip II. of Spain. Charles V. was succeeded by his son, Philip II. of Spain, a sovereign who made for himself a deep mark on the world's history. Philip was born at Valladolid in 1527. In 1543 he married Mary of Portugal, who died three years after, and in 1554 he became the husband of Mary Tudor, Queen of England. The abdication of his father consigned to him a vast dominion, including Spain, the two Sicilies, Milan, the Low Countries, Mexico, and Peru. The resources of the State had been much exhausted by previous wars, and Philip had but little opportunity of making good these losses, even if he had been a sincere and capable economist. The first war of his reign was made against the league formed by Henry II. of France and Pope Paul IV. Philip won two decided victories over the French, and Henry of France was compelled to agree to a peace. On the death of his wife, he married Isabella of France.

"Dictator to Europe." Philip was a man of narrow mind, although of much political capacity, and ambitious of extreme power. His resolute aim was to reign as a despot over his own dominions, and to make himself a dictator to Europe in general. He put himself at the head of the Catholic party, and worked deliberately for the suppression of all free institutions within his own states. He made full use of the machinery established by the Inquisition for the purpose of extinguishing all religious sects throughout his territories; but he overdid the work. In the Low Countries his tyrannical policy roused the whole people of the Netherlands to a revolt, which ended in the independence of that country. The great failure of Philip's life came from his extravagant attempt to conquer England. The destruction of the Spanish Armada is one of the memorable events of European history. His whole reign was, in fact, a series of failures which greatly increased his financial troubles at home, and his persecutions brought him enemies far and wide. His later years were a period of utter disappointment, of breakdown in health and hope. He died on September 13th, 1598. With the revolt of the Netherlands and the defeat of the Spanish Armada, the history of Spain as a great, and sometimes a domineering, power in Europe may be said to have come to an end.

THE NETHERLANDS

The struggle for independence and the final success of the Netherlands gives to the history of Europe one of the most interesting and important of its chapters. That portion of the northern Netherlands known as Holland was governed for some centuries by a line of counts under the over-rule of the German sovereigns. It was annexed to Austria, and finally came under the dominion of Philip II. of Spain.

The Revolt of the Netherlands. The people of the Netherlands were among the earliest and the most resolute to join the Reformation, and Philip made merciless use of all the forces of the Inquisition in the futile effort to coerce the indomitable Dutchmen into a renunciation of their new faith. It is said that about 100,000 human beings must have lost their lives during Philip's campaigns of persecution. The people of Holland were not, however, to be persecuted out of their religion or their nationality, and as Philip was evidently determined not to mitigate his policy, they saw that there was nothing left for them but to rise in rebellion. The leading men among the Dutch kept firmly in their minds the fact that they had, as their last resource, an ally against which even the power of Philip II. could not contend—the sea, which rose above the level of their shores, and had to be kept from washing over them by gigantic and elaborate dykes and other such artificial means of protection. In 1566 the Dutch nobles formed a confederation called "Les Gueux" ("The Beggars"), a name which had its origin from an epithet given in contempt to a body of 300 deputies from the Low Countries, headed by two nobles, who ventured to present the petition for the abolition of the Inquisition in Holland and Belgium. This name, thrown out in scorn, was taken up by the deputies and accepted defiantly as their title. The peaceful deputation soon changed into a warrior band and made the name of the "Beggars" to ring in renown throughout Europe.

William the Silent. One of the leading men of that era was William Prince of Orange, who succeeded to large estates in Holland, and showed even in his earliest years so much military and statesmanlike capacity that he was appointed by Charles V. Commander-in-Chief of the Netherlands when only twenty-two. William is known to all history as "William the Silent." It is, however, certain that among other great qualities he was an accomplished orator, who never failed to make use of his powers of speech when any great object was to be served.

On one memorable occasion, in 1560, William was put in possession of a State secret by Henry II. of France, at a time when he was a hostage in Henry's dominions. This secret, which was a project concocted by France and Spain for the destruction of all the Protestants of France and of the Netherlands, was confided to him while hunting in the forest of Vincennes by the King of France, who assumed that the Prince of Orange, like most other men of rank at that time, had no sympathy [illegible] the

Protestant cause. William of Orange was then a Catholic, though he became a Protestant soon after. Had William entered into any controversy on the subject, he knew that means would be taken to prevent him from spreading alarm as to the intended policy of extirpation.

He listened, therefore, in absolute silence, and was able to forewarn his countrymen and prepare measures of national defence. He began by opposing the persecutions started by Philip, and in 1567 resigned all his offices of state, and openly avowed himself a member of the Protestant Church. Philip of Spain sent the Duke of Alva to the Netherlands at the head of a large army, and with unlimited power to maintain the Government of Spain there. The Duke of Alva did his best to carry out the King of Spain's wishes by merciless bloodshed. William was proclaimed a traitor by Alva, and as the whole country was now rising in revolt, the proclaimed traitor was at once chosen by the Hollanders as their commander by sea and by land, and under his guidance the revolt of the Netherlands was successfully carried on. Until the rising of the Gueux, the Spaniards had held unchallenged mastery over the Netherlands, but from that time a revolt went on gaining in strength with every day.

Union of the Northern Provinces. The union of all the northern provinces was thoroughly established in 1579, and in five years more the whole united Netherlands had renounced for ever their allegiance to the power of Spain. Much was yet to be accomplished before the absolute independence of the new state could be forced upon the recognition of Spain. The Dutch were determined to fight on to the last, and it was one of their resolves that, should the worst come, they would destroy the dykes which kept out the sea. 173.

Long before the struggle had gone so far as to call for such a policy of self-destruction, the gallant Hollanders had suffered a heavy loss by the death of their illustrious leader, William the Silent. The King of Spain, through the Duke of Alva, proclaimed William of Orange a traitor, and set a price upon his head—the sum of 25,000 gold crowns, and as a result of this measure an assassin named Balthasar Gerards shot William with a pistol bought with money the Prince had given him in alms, and killed him at Delf, on July 10th, 1584. Nothing can give better evidence of the strength of the national cause and of the enthusiasm with which William had inspired his fellow countrymen than the fact that his death only seemed to nerve the Hollanders to fresh effort.

Much sympathy was felt in England for the Dutch in the struggle which they were carrying on, and in 1585 some 6,000 men were sent to help them. Spain had made many enemies for herself throughout Europe, and Queen Elizabeth of England was always ready to lend a helping hand to any opponents of Spanish policy, although the continual rivalry between the two great powers had not yet reached to that form of open war it was soon to assume. The Dutch knew well how to maintain their struggle, and how to avail themselves in the most effective manner of any help offered to them. It became evident that there was no possible means of reducing the Dutch once again to servitude under the King of Spain. The northern provinces of the Netherlands achieved their independence, and thus became a new self-ruling European state. Those provinces of the Netherlands which we now know as Belgium remained, for a time, under the dominion of Spain or of Austria.

GERMANY

The German populations were, about the tenth century, forming themselves into something like cohesive and powerful states, although many of them yet remained in a condition which showed uncertainty as to whether they were destined ultimately to form part of a people subject to a foreign power, or to lose their nationality by becoming absorbed into the dominions of some larger state. Austria, the name of which signifies "Eastern Kingdom," had undergone many invasions and occupations since the days when it was part of the Roman Empire. Charlemagne, in re-establishing the various states over which he had acquired dominion, made Austria a margraviate, ruled over by a margrave. Later on the margraviate was raised to a duchy, and still later to an archduchy.

Frederick II., who reigned over the Empire of Germany from 1212 to 1250, was one of the most remarkable sovereigns of the Middle Ages. With his son Conrad, who reigned for four years, ended the Hohenstaufen line, and he was succeeded by many princes who ruled—sometimes contemporaneously—during a period known as the Great Interregnum, which lasted till 1273, when Rudolf I. of the Austrian House of Hapsburg, came to the throne. For nearly two centuries from this time the history of the German Empire is but the record of a succession of rulers.

Maximilian I. succeeded his father, Frederick IV., in 1493, and his marriage with Mary, daughter of Charles the Bold of Burgundy, involved Maximilian in European politics. He made many improvements in the laws and the internal affairs of the Empire—originating the Imperial Chamber and the Aulic Council.

The Reformation. In his reign began the Reformation movement, to which he was opposed, and the success of Luther's preaching, but the establishment of the Protestant religion in Germany did not take place until the reign of his grandson, Charles V, grandson, also of Ferdinand and Isabella of Spain, who reigned from 1519 to 1556.

For a long time the Emperors of Germany retained also the title of Emperor of Rome, by which Charlemagne was crowned in 800, by Pope Leo III. Otho the Great, who was crowned by Pope John XII., in Rome, in 962, was the first who was called Sovereign of the Holy Roman Empire. The Empire, under its various denominations, was made up of all manner of European states enclosing within the one ruling system several different nationalities. Nor did these populations seem to be held together by any influence more successfully assimilating them than the strength of the German ruling power. For some time the Netherlands became part of the Empire of Austria by the marriage of the

Austrian Prince Maximilian with the daughter of Charles the Bold, and not long after Spain became a dominion attached to Austria by the marriage of Philip of Spain with the heiress of Aragon and Castile.

SWITZERLAND

Helvetia, or Switzerland, after the rule of the Roman Empire had ended, was ravaged by the Huns, and in 450 was invaded by the Burgundians and the Alemanni. In the fifth century it was ruled by the Franks of the Merovingian line, and somewhere about this period many of the famous monasteries were founded. Much of what is now Switzerland was, in the Middle Ages, part of the Holy Roman Empire, and was therefore, in the thirteenth century, under the rule of Rudolph of Hapsburg, the Sovereign of Austria.

The men of some of the Swiss cantons, Uri, Schwyz and Unterwalden, early in the fourteenth century formed a league and covenant against the rule of Austria—more, indeed, against the rule of the subordinates of the Emperor than against the Emperor himself—and other cantons quickly joined the *Eidgenossen* (the confederates), as they were called. In 1307 three of the leaders of the confederates met by the Lake of Lucerne, and swore to free their country from the tyranny of Austria, and in the following years many other cantons joined the confederation. In 1315 they put to rout the army of Leopold of Austria. By the middle of the century most of the cantons had joined the confederates, and the Austrians were defeated in 1386 at Sempach, in 1388 at Näfels, and in 1393 the Swiss drew up the famous Convention of Sempach.

In 1476 the Swiss encountered Charles the Bold on the French frontier. They defeated him at Grandson, and again at Morat, and in the following year, before the walls of Nancy, in which engagement Charles the Bold was slain.

The Story of William Tell. The story of the Swiss uprising is so much associated with the name of William Tell that we will mention the legend here in passing. The story tells how Gessler, the representative of Albert II. of Austria, tried to compel the Swiss to do homage to the hat of the prince set up on a pole in Altorf; how William Tell, refusing to offer this homage, was ordered to shoot an apple off the head of his son. Tell accomplished this feat without injuring his boy, but avenged himself by putting the village tyrant to death. Then broke out the movement which ended in securing the entire independence of Switzerland.

In the sixteenth century the Protestant Reformation, led by Zwingli, arose in Zurich, and quickly spread over many of the northern or German cantons of Switzerland. Some of them, however, remained Catholic, and in 1531 war broke out between the followers of the two faiths. Zwingli was killed, and the Zurichers were defeated at the Battle of Kappel. Four years later Geneva became a Republic with new civil and ecclesiastical laws, under Calvin, and after this Protestantism spread into the west of the country. During the Thirty Years War Zurich and Berne helped to maintain the neutrality of Switzerland, which was recognised as an independent state by the Treaty of Westphalia in 1648. This independence Switzerland has ever since maintained.

HUNGARY

Hungary was first formed into a kingdom by Stephen in 1000. The title of "Apostolic King" was conferred on him by Pope Sylvester II. for his work in the spread of Christianity, and the crown he then received was worn by all kings of Hungary since. After his death in 1038, unsuccessful efforts were made to re-establish paganism. Stephen founded many religious and civil institutions—the Ecclesiastical Organisation, the Municipal Councils, and the National Council—afterwards the Diet of the State.

In 1222, during the reign of Andrew II., the "Golden Bull," the Magna Charta of Hungary, was granted, and nine years later its privileges were much extended. Hungary was invaded by the Mongols in the reign of Béla IV., and German colonists were introduced by him, as the country had been much depopulated by the Mongol massacre. Andrew III., who died in 1301, was the last sovereign of the House of Arpád, and on his death the succession was contested. Seven years later, Charles Robert of Anjou became king, and reigned until 1342. He did much to improve the condition of his adopted country, and under his rule and that of his son, Louis the Great, Hungary took a high place among the nations.

Matthias of Hungary. When Ladislaus Posthumus died, in 1457, he was succeeded by Matthias, the son of the great Hunyady—the famous general whose life was one long crusade against the Turks. The reign of Matthias saw the greatest era in the history of Hungary. He went to war with Bohemia, and became king of it and of Moravia. He made war with Turkey, and regained the Southern Provinces which Turkey had held. In 1485, he made Vienna the capital of Hungary.

Matthias was also renowned for his statesmanship, his justice, and his encouragement of arts and letters. On his death the country was given over to internecine strife, and rapidly declined in prosperity. It was invaded by the Turks in the reign of Louis II., and Louis himself was killed. The crown was then contended for by John Zapolya and Ferdinand II. of Austria. As Ferdinand had the support of the Hungarian nobles, Zapolya had to renounce his claim, and Hungary thus came under the sway of the House of Hapsburg. Since that date the history of Hungary is connected with that of Austria. Under a succession of Austrian sovereigns there were many wars with Turkey, and much strife between the Catholic kings and their Protestant subjects. There were many risings, also, against Austrian rule, and these conditions lasted until 1825, when the National Diet, which was convoked by Francis I., opened a new era in the history of Hungary.

Continued.

THE NAVAL OFFICER

From Cadet to Admiral. Entrance Examination. Naval Colleges. Midshipman. The Ladder of Promotion. The Officer's Pay

By C. DUNCAN CROSS

We have shown how a seaman may rise in the Navy from a second-class boy to commissioned rank; we shall now proceed to explain how a boy more favoured with fortune's blessings rises from midshipman to Admiral of the Fleet. It will be observed that we deal in this section only with the executive branch of the Service, the Paymaster branch being dealt with in the Civil Service sections on page 3195.

Efficiency of the Naval Officer. To-day the cry of the Navy, as in every other profession, is for the life-trained officer, for there is so much to learn in our complicated boxes of machinery that to know even a part means a life study. For a man who is to lead men, also, the training in the habit of obedience and discipline cannot begin too early. In the case of other services, charges are sometimes levelled that the training methods are inefficient, and that the living is extravagant. This, however, cannot be said of the Navy, where the keynote of naval education is thoroughness, and where economy of living is the watchword. From the moment a boy joins the training college he is taught that strict attention to work is the only avenue to promotion, and his allowance of pocket-money would compare badly with that of a public school boy of his own age. After reaching the rank of lieutenant, a young man can live fairly comfortably on his pay.

It must be understood that at present the representatives of two systems of education are working side by side in the Navy. Under the old system boys entered for whatever branch of the Service they fancied—executive, Engineers, or Royal Marines. The result was a race of specialists—each man excellent in his own department, but knowing very little about the work of other branches of the Service. To remedy this state of things a new system has been introduced to produce a type of officer with a more comprehensive knowledge and wider sympathies. The age of entry has been lowered, so that to-day a boy must decide practically on leaving his preparatory school that he desires to enter the Navy.

The Preliminary Examination. The training begins at Osborne College. To be admitted, a boy must be of pure European descent, and the son of natural born British subjects, or of parents naturalised in the United Kingdom. An application for nomination should be addressed to the private secretary of the First Lord of the Admiralty, and should not be made before the boy is eleven years old. On receiving a nomination from the First Lord, the candidate is required to present himself before a committee, not for an examination of his book knowledge, but so that the committee may have an opportunity of judging from his conversation and manner what sort of a boy he is, and whether he is likely to make a good officer when he is grown up. The candidate is required to produce a certificate of birth or its equivalent, a certificate of good conduct from the master of the school or schools at which he has been educated for the two previous years, and proofs of good health and freedom from constitutional disease or hereditary taint of any kind. A severe medical inquiry has to be faced, and then the qualifying examination, which embraces the following subjects:

English: Dictation, simple composition and reproduction of the gist of a passage read twice by the examiner.

History and Geography: The whole outline, with special reference to the British Empire.

Mathematics: Arithmetic (simple), including decimals, fractions, mensuration of area and capacity, money, proportion, etc. Algebra, up to simple and simultaneous equations. Practical geometry (angles and constructon of angles, squares, parallelograms, and division of straight lines into equal parts). Theoretical geometry (definitions, the substance of theories contained in Euclid Book I, propositions 4—6, 8, 13—16, 18, 19, 26—30, 32—34, and very simple deductions from these).

French or German: Simple examination, with great stress on the *vivâ voce* part.

Latin: Easy passages for translation, English-Latin and Latin-English, and simple grammatical questions.

Specimen examination papers can be obtained.

Cost of Training. This examination successfully passed, the lads have to present themselves in uniform at Portsmouth Dockyard on the appointed day, and are taken across to Osborne by a Government launch. Here the foundation of the life-work is laid.

Beyond the cost of the kit, which consists of bed-linen and towels as well as clothes, the cost to the parent is at the rate of £75 per annum in three (advance) instalments of £25. Over and above this, to cover the miscellaneous expenses, such as washing, instruments, books, sports, and pocket-money, another £8 per term should be expended. In a few cases the Admiralty allow the sons of officers in the Army, Navy, or civil servants under the Admiralty to enter at a reduced payment of £25.

Osborne College. The Naval School at Osborne is organised on the lines of the best public schools, special attention being directed to fit the cadet for his career, not only as a skilful

seaman, but also as an officer and a gentleman. Examinations are held at the end of every term, and should a cadet fail to satisfy the Lords of the Admiralty his parents may be asked to withdraw him at any time. A declaration of willingness to do this has to be signed at the time of the boy's joining, together with a declaration of willingness that the boy shall enter that branch of the Service for which he may seem to be best fitted, whether engineering, marine or general executive. At Osborne, a splendid workshop has been fitted up, and the cadets spend quite half of their time in practical and theoretical work connected with engineering or in studies closely bearing upon it. There is a ship attached to Osborne in which the cadets go for cruises lasting six weeks for practical instruction in seamanship. Physical education also is well looked after.

Dartmouth College. After two years, the cadet passes on to Dartmouth College for another two years, to complete his preliminary studies. The course of this four years' training has included the study of mathematics, mechanics, heat and electricity, the theory and practice of engineering; English and French composition and literature, together with some German; history and geography, navigation, and the elements of seamanship; religious knowledge; physical education. The cadet at Osborne has already had a course lasting some six weeks, and, leaving Dartmouth, he goes to a training cruiser for more practical instruction in navigation, seamanship, and engineering than can be obtained ashore. Until he reaches the rank of sub-lieutenant his parents are required to make him an allowance of £50 a year.

Midshipman. At the end of two terms on the training cruiser he is drafted with a batch of youngsters of his own seniority to a sea-going ship as midshipman. This, however, does not mean that his education is complete. True, he is no longer under a civilian instructor but he devotes his whole time to learning his professional duties under one or other of the officers, about one-third of his days being spent in the engineering section. On completing three years' service as a midshipman, a serious examination has to be passed for acting sub-lieutenant in seamanship and practical engineering; he attends the next examination in navigation and general subjects, and he attends short courses of gunnery, torpedo work, and pilotage at the depôts, each of which is followed by an examination on the work studied in the course. Those who show aptitude and special ability are then allowed to go through a further and more comprehensive course, lasting six months, at Greenwich Naval College, which fits them for specialising in any particular branch.

The sub-lieutenants who do not qualify for the extra course are immediately sent to sea, and are joined by the Greenwich students at the completion of their course. Sub-lieutenants must serve at sea for at least one year before being promoted to lieutenant, and must obtain from their captain a certificate that they are efficient in the duties of officers of the watch.

Under the new scheme of education the lads who have all been trained under the same system are now apportioned to the branch for which they are most fitted, and they become specialists in engineering, in gunnery, torpedo, or navigation, being denoted by the letters E, G, T and N, while some go to the Marines, whom we shall call M. The rest become general service lieutenants, available specially for watch-keeping, discipline, and seamanship.

Lieutenant. On promotion to lieutenant, the dividing line comes. Officers for gunnery go to Portsmouth for a year; for torpedo-work, to the Vernon Torpedo School; for navigation to Greenwich; for engineering to Keyham, to increase their practical knowledge and to study dockyard work and repairs. Lieutenants (M) go to one of the Marine divisions to learn their special military duties.

Of these specialists a few of the best are allowed a further course of instruction to fit them for the higher grade of lieutenant, which, for the sake of clearness, will be called G 2, T 2. For these the higher course lasts for one year while for E 2 the course is two years. Of the general service lieutenants a few are selected for instructional purposes and undergo a short course to fit them for their work.

Branches of the Service. Now it has been explained how the lads trained together in the same system as far as the rank of lieutenant have been broken up into three main divisions—engineers, Marines, and what we shall call, for want of a better term, general executive officers, which divisions have been subdivided into specialists and non-specialists. It remains to be shown what these young men will do with their careers. Will the specialists continue as specialists to the end of their days, or do they foster the hope of one day commanding a fleet?—for it is still open to the engineer to revert to the main channel and go through the ordinary course of promotion.

In exceptional cases, it is possible for the lieutenant (E 2) to revert, but it is most unusual, and indeed, undesirable, for he is throwing away his special education and his chance of quicker promotion. He will, therefore, look to the engineer branch to provide his fortune, and he will rise in the ordinary course to commander (E 2), captain (E 2). And although he

PAY OF OFFICERS IN THE ROYAL MARINES

	One Year. £ s. d.	One Day. £ s. d.
Colonel Commandant ..	730 0 0	2 0 0
Major	293 16 1 to 337 12 6	0 16 1 to 0 18 6
Captain	220 10 5 to 266 2 11	0 12 1 to 0 14 7
Lieutenant	115 11 8 to 135 7 1	0 6 4 to 0 7 5
Second Lieutenant ..	95 16 3	0 5 3
Quartermaster	173 7 6 to 282 17 6	0 9 0 to 0 15 6

RATE OF PAY OF ALL RANKS OF OFFICERS IN THE NAVY

——	Per Annum.	One Day.	Special Remarks.	
	£ s. d.	£ s. d.		
Admiral of the Fleet	2190 0 0	6 0 0	With Table money varying between £547 10s. and £1,642, according to station and the amount of entertaining required.	
Admiral	1825 0 0	5 0 0		
Vice Admiral	1460 0 0	4 0 0		
Rear Admiral	1095 0 0	3 0 0		
Commodore (1st Class)	1095 0 0	3 0 0		
Captain of the Fleet	1095 0 0	3 0 0		
Captain	410 12 6 to 602 5 0	1 2 6 to 1 13 0	With Command money varying from £91 5s. per annum to £328 10s., according to rank and circumstances.	
Commander ..	365 0 0	1 0 0	Command money when commanding a ship, or on special service, £45 12s. 6d. to £68 8s. 9d.	
Lieutenant, under 8 years	182 10 0 to	0 10 0 to	Command money, £45 12s. 6d. to £68 8s. 9d. Senior Lieutenant of a ship, £27 7s. 6d. to £45 12s. 6d. Gunnery or Torpedo Lieutenants, £36 10s. to £73. Navigating Lieutenant, £45 12s. 6d. to £73.	
„ 14 years	310 5 0	0 17 0		
Lieutenants promoted from Gunner or Bo'sun, etc.	237 5 0 to 273 15 0	0 13 0 to 0 15 0	According to seniority. Extra allowances for specialists.	
Sub-lieutenant ..	91 5 0	0 5 0	Command money £36 10s. per annum.	
Midshipman	31 18 9	0 1 9		
Naval Cadet	18 5 0	0 1 0		
Engineer Rear Admiral	1095 0 0	3 0 0		
Engineer Captain	638 15 0 to 730 0 0	1 15 0 to 2 0 0		
„ Commander	438 0 0 to 602 5 0	1 4 0 to 1 13 0		Extra pay if in charge of engines. £18 5s. to £91 5s.
Engineer Lieut. ..	182 10 0 to 365 0 0	0 10 0 to 1 0 0	According to seniority.	
„ Sub-lieutenant	136 17 6	0 7 6		
„ Lieutenant promoted from warrant rank	264 12 6 to 301 2 6	0 14 6 to 0 16 6	According to seniority.	
Chaplain or Instructor	219 0 0 to 401 10 0	0 12 0 to 1 2 0		
Inspector-General of Hospitals	1300 0 0			
Fleet Surgeon ..	492 15 0 to 657 0 0	1 7 0 to 1 16 0		
Staff Surgeon ..	365 0 0 to 438 0 0	1 0 0 to 1 4 0		
Surgeon	255 10 0 to 310 5 0	0 14 0 to 0 17 0		

will go to sea from time to time to keep in touch with modern practical engineering, the Admiralty will be glad to make use of his services ashore and in the higher ranks of the dockyard advisers. The Marine lieutenant, in some cases, will revert to the general executive and be appointed commander in his proper turn; for he is to-day not only the musketry officer but he can also take his turn in watch-keeping and the general duties of the ship. On the other hand, he may qualify for commander (M) and then revert to captain in command of a ship. A third possibility, of which a few will avail themselves, is to continue discharging the duties of Marine commander, and look for promotion in the Marines to the higher rank of captain (M), major (M), and colonel to general.

The Ladder of Promotion. For the rest, the general service lieutenants, there is a long, weary wait for their next step. After five years' service in the rank the officer has to pass an examination in naval law, court-martial, naval history, strategy and tactics, besides the examination in the general professional subjects. In due course his turn for promotion comes and he is promoted to commander, probably in ten or twelve years. It must not be supposed that the time has been monotonously spent. He has been changing from ship to ship, has been in torpedo boats, destroyers, cruisers and battleships, and has served at home and abroad. He has attended qualifying and requalifying courses and has every year been learning something of the management of ships, of guns and of men. So that at about the age of thirty-five he is a man of wide knowledge and experience besides having passed about twenty severe examinations. Another four to six years as commander should see him promoted to captain, though still he has not completed his education, but must go to Greenwich to learn the higher teachings of strategy. In the end he is promoted at last to admiral after eleven to fifteen years in command of ships.

We have not yet touched upon two important branches of the Service—the medical and the clerical. They are, however, of purely technical interest, and are open only to men who have already received a special education. It suffices, therefore, to say that a proof of professional knowledge must be produced in the form of a degree, and that promotion is gained by seniority tempered by a certain amount of selection. Doctors enter as surgeons and rise through staff-surgeon to fleet-surgeon; and there are one or two good appointments for the fortunate both at home and abroad.

For chaplains there is little promotion in the ordinary sense, but their pay increases by length of service; and there are a few livings ashore belonging to the Admiralty which are given to men who have been naval chaplains as a reward for good service. The pay of a chaplain or naval instructor ranges between £219 and £401 10s. per annum.

Army and Navy concluded

CHEMICAL ANALYSIS

Apparatus used in Chemical Analysis. Qualitative and Quantitative Analysis. Examinations and Confirmatory Tests

Continued from page 4319

By CLAYTON BEADLE and HENRY P. STEVENS

THE word *analysis* is derived from the Greek ἀναλυω (analuō), to loosen; and, like so many general terms of this description, can be used in several different senses.

In a chemical sense we refer to the loosening or breaking down of a substance, or mixture of substances, into their ultimate constituents; just the reverse of what is understood by *synthesis*, which means the building up of a substance from simpler constituents. The meaning which we shall attach to the words Chemical Analysis in this article is somewhat narrower. We shall break down or resolve substances merely for the purpose of ascertaining of what they consist and in what proportions the constituents are present. Put shortly, the objects of a chemical analysis are (1) the identification of a substance, (2) the detection of the components in a mixture of substances, (3) the determination (estimation) of the amounts in which they are present.

Qualitative and Quantitative Work. Thus, supposing we are analysing a silver coin, we might be required to identify the metal of which the coin is made, in this case silver; secondly, to detect the presence of other substances, such as copper; and thirdly, to estimate the quantities of silver and copper alloyed together in the coin. The identification and detection of substances and mixtures are operations which naturally precede the estimations of the proportions in which they are present. We may, therefore, regard analysis as comprising two branches, *qualitative* and *quantitative*. We shall start with the qualitative analysis, in which we "convert the unknown constituents of a body into certain known forms of combinations; and we are thus enabled to draw correct inferences respecting the nature of these unknown constituents" (Fresenius).

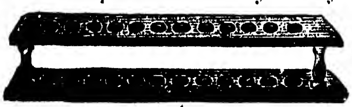
In what follows, the student will find given an outline of some of the more important methods of analysis, which will enable him to form a general idea of how such analyses are performed. In some cases, methods of analysis are fully described, but in most cases it has been found impossible to do this. For full details the student may consult the "Qualitative and Quantitative Analysis" of Fresenius, and the "Volumetric Analysis" of Sutton. These are the standard works on the subject, and on them most of the smaller treatises are based. The student may also consult Clowes and Coleman, who have compiled useful textbooks on both qualitative and quantitative analysis. The latter, with which we are well acquainted, is a particularly useful book for the student. The theoretical side of analysis is beautifully worked out in Ostwald's "Analytical Chemistry." No amount of reading can, however, replace practical work in the laboratory; and, in doing accurate work, there are numerous precautions to be taken and difficulties to be overcome, which will not be realised merely by reading these articles, and which are met with only in actual practice. We have, however, where possible, drawn the student's attention to the more obvious pitfalls, and with some personal instruction he should, without much difficulty, be capable of carrying out those analyses where full details are given.

Theoretical Considerations. Substances are identified by their properties which appeal to our senses. It is, of course, impossible to take all these properties into consideration, but if we prove that two substances agree completely in a few instances, it is usually sufficient. Thus, a black solid giving purple vapours when heated and a blue colour with starch paste is almost certainly iodine. We know of no other substance coinciding in all these three properties with iodine, and may therefore take these coincidences as sufficient proof of identification. On the other hand, we are acquainted with several white solids which give colourless vapours, and to distinguish between them we must note other of their properties. By taking as wide a range as possible, we reduce the possibility of error. The properties we make use of are of two kinds: first, the inherent properties—those peculiar to the substance itself, such as colour, odour, density (mass per unit volume); secondly, what for want of a better word, we may term *reactions*—that is, those changes brought about by treating with other substances, as well as those due to changed environment.

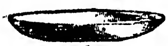
Reactions. The second class is the more important for our purpose and includes a wider and more varied range of phenomena, among which is included the *chemical and physical reactions*. By these we understand changes brought about by altering the conditions under which the body exists. Thus, in identifying iodine, we obtained it in the form of a purple vapour by changing one condition—namely, temperature. By varying the temperature and noting the behaviour of the substance under examination, a great deal of information may be gained, and the applicability of this method is further extended by using instruments (thermometers) for accurately measuring temperatures. In addition to observing a change in the state of aggregation—say, from solid to liquid—on raising the temperature, we may note the exact temperature at which the change takes place (melting point). This principle is one of those most commonly used in identifying organic substances.

Numerous other instances might be cited, and the student will meet with other examples in what follows. The changes we have considered may be classed under the heading of *physical reactions.* The chemical reactions are of equal, or of even greater, importance. In order that such may take place, two substances must be brought into intimate contact with one another, and in the case of solids, this is most generally effected by dissolving them in a common solvent, such as water. On dissolving each separately, and mixing the solutions, a "precipitate" will be formed if, by their mutual reaction on one another, they are capable of forming a substance insoluble in water (the precipitate), which promptly separates out in a finely divided state.

Precipitates, and What They Teach. As to chemical apparatus, we require little else for qualitative analysis beyond a basket of test tubes, a test-tube stand [1] to hold them, some watch-glasses [2] and stirring rods, a platinum wire and Bunsen burner [3] and a set of reagents—that is, chemical substances usually in solution, which bring about characteristic reactions with the substances which we are testing. In addition, a funnel and filter paper will be required. Fig. 4 shows the different shapes in folding a filter paper and fitting it into a funnel. The most common method, and that most generally applicable, is to add the reagent to a solution of the substance to be tested, and note whether or not a precipitate is formed. Thus, a solution of hydrochloric acid added to a silver salt, produces a white precipitate of silver chloride. As, however, hydrochloric acid produces a white precipitate with other substances besides silver salts—as, for instance, salts of mercury (mercurous) and lead—it is usually necessary to examine the precipitate further in order to make certain that the substance is what we imagine it to be. The white precipitates formed from silver, mercurous, and lead salts, differ in their properties, so that we can distinguish between them. Thus, the lead compound known as *lead chloride* is soluble in hot water, separating out again on cooling, in tiny needle-shaped crystals. The lead chloride precipitate is seen in 7. Being heavy, it rapidly settles to the bottom of the test tube. Fig. 8 shows the needle-shaped crystals obtained by dissolving in hot water and setting aside to stand. It is not changed in appearance by adding ammonia to it, while on the other hand, mercurous chloride is turned black by this treatment, and silver chloride is dissolved. Where possible, the precipitate should be washed before applying the latter tests, as other substances in solution might interfere with the reactions and complicate them. Washing is effected by filling the test tube with water, allowing the precipitate to settle to the bottom, carefully pouring off the water, leaving as much precipitate behind as possible, adding more water, and repeating the process once or twice. Fig. 6 shows a "clotted" precipitate of silver chloride which has been washed in this manner.



1



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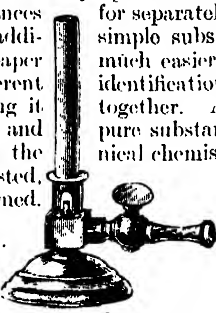


3

Some substances when heated with acids evolve gases, and this property may be made use of in analytical work. Thus, carbonates, such as chalk, give off carbon dioxide gas when treated with hydrochloric acid. Here also, it is necessary to go a step further and to identify the gas. It happens that sulphides also give off a gas when treated with hydrochloric acid; but the gases have different properties. Thus, carbon dioxide gas may be poured off into a test tube containing lime water, when a precipitate of calcium carbonate will be formed on shaking the liquid up with the gas. It is, moreover, odourless. On the other hand, sulphuretted hydrogen has a peculiar, offensive odour, and produces a metallic stain on a piece of filtered paper saturated with a solution of the silver or lead salt.

Insoluble Substances and Preliminary Work. Sometimes substances are insoluble in water and acids, and appear to be very inert. The identification of these substances is difficult. However, as there is only a limited number of them, their individual properties can be learnt, and they must be tested for separately. Of course, the identification of simple substances such as simple salts is a much easier operation than the detection and identification of a number of substances mixed together. As, however, in technical work pure substances are seldom met with, a technical chemist has to deal with mixtures even though some of the constituents are present in small quantities as impurities. The reactions of different substances with reagents have been carefully studied and tabulated, so that a systematic examination may be made. It is usual, however, before proceeding with the systematic examination, to make a preliminary examination, which often furnishes valuable clues to the nature of the substance. As we have already shown, any property of a substance, and any reaction in which it is capable of taking part may be made use of for its detection and identification, so that a knowledge of analysis, and a knowledge of general chemistry go hand in hand, and it is therefore impossible to be an expert analyst without a wide knowledge of chemical reactions.

Group Reagents. In the course of systematic analysis it will be found that hydrochloric acid produces a white precipitate with silver, mercury or lead, owing to the formation of the chlorides of these metals, and as they behave alike in this respect, and differ from the salts of all other metals, they are classed together in Group 1, of which hydrochloric acid is the "group reagent." If no precipitate is ob[illegible] the student passes on to Group 2, of which sulphuretted hydrogen is the group reagent. This forms a precipitate with the salts [illegible]

metals in Group 2; the other groups have their corresponding group reagents.

Observation and Experiment. It is not possible to proceed mechanically in making an analysis, as the general rules which we shall give are modified by varying conditions. Even in the detection of simple salts the student may make serious errors unless he reason out his methods carefully, and take the trouble to understand thoroughly what he is doing.

We remember that on one occasion a student was given a yellow-coloured solution to test smelling somewhat of sulphuretted hydrogen. Taking no notice of these data, he proceeded blindly to test for metals of the first group by adding hydrochloric acid, and, obtaining a whitish precipitate, immediately concluded that a salt of silver, mercury, or lead was present. If he had thought a moment, and taken trouble to examine the precipitate, he would have seen that it differed totally in appearance from the chlorides of any of these metals. As a matter of fact, he had been given a solution of an alkaline sulphide to identify, and the hydrochloric acid added neutralised the alkali, precipitating sulphur, which he mistook for the chloride of a metal of Group 1. The sulphur precipitate is seen in **5**; its appearance may be contrasted with **6** and **7**. The incident mentioned was a very obvious case of want of care in observation and lack of knowledge or forethought; but similar things can happen, and happen more easily in difficult analyses, if the student does not understand thoroughly what he is doing.

4. GLASS FUNNEL AND FILTER PAPER

Hints for Practical Work. When working in the laboratory only small quantities need be used, both of the substance to be tested and of the reagent. If a quantity of the liquid to be tested sufficient to fill the test tube to a depth of ½ in. or so be taken, that will be ample. Compare **5** to **12**. The reagent should be added gradually, especially in the case of strong acids. The contents of a test tube should not be thrown down the sink directly after adding the reagent if a precipitate be not immediately apparent. Some precipitates, such as sulphate of calcium or strontium form slowly. Others, as aluminium hydroxide, are very transparent and gelatinous in appearance, and may easily be missed. The precipitate of aluminium hydroxide becomes denser and settles on boiling [**9**]. When a precipitate is formed, its appearance should be noted before throwing it away. Thus, it is advisable to replace the test tubes in the stand until the condition of the precipitate is properly understood and carefully noted. The appearance of precipitates varies very much. Thus, a flocculent, or "clotty" precipitate of silver chloride [**6**] is very characteristic, and easily distinguishable from a fine, granular one, such as sulphate of barium [**12**]. After boiling, the precipitate settles more readily [**11**]. When heating the contents of a test tube in a Bunsen flame, the tube should be held with the mouth pointing away from the operator, and the tube constantly shaken; there will then be less likelihood of cracking the tube, and if the contents boil suddenly and spurt out, as they sometimes do, there is less danger of them striking the face.

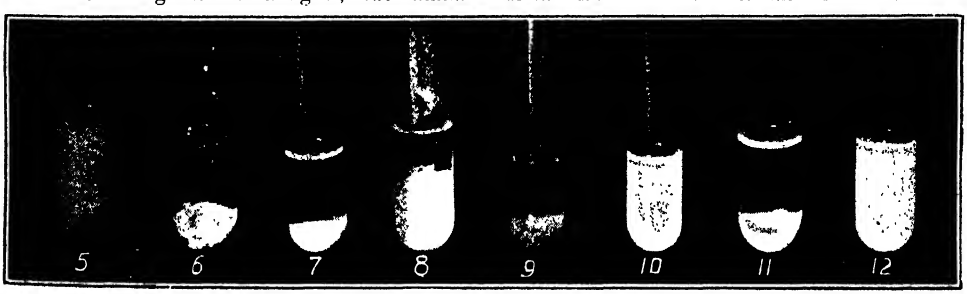
With these remarks, we proceed with the preliminary examination.

Preliminary Examination. The substance is assumed to be in a solid state. Note the colour and general appearance. Many metals have coloured ions and form characteristically coloured salts – for instance, *copper*, blue and green; *cobalt*, blue and pink; *ferrous iron*, green; *ferric iron*, red to brown; chromium, yellow to red. *Mercury*, *lead* and some other metals give characteristically coloured compounds, while those formed from others, such as *aluminium*, *barium*, etc., are generally white.

Heat a little in a dry tube, preferably a narrow hard-glass tube, but a test tube will do, and note what happens.

The following conclusions may be drawn:

(1) If it changes colour—to black (carbonisation), *organic matter*; to brown, *cadmium*



TYPICAL PRECIPITATES

5. Sulphur recrystallised **6.** Silver chloride precipitate washed **7.** Lead chloride freshly precipitated **8.** Lead chloride **9.** Aluminium hydroxide **10.** Silver chloride freshly precipitated **11.** Barium sulphate after boiling **12.** Barium sulphate before boiling

carbonate; to yellow (while hot), *zinc oxide* or *carbonate*.

(2) If it sublimes, note colour and appearance of sublimate—that is, the substance that condenses from the fumes. The sublimate may be white, *ammonium salts*, *mercury*, *antimony* or *arsenic*; metallic mirror or globules, *mercury*, *arsenic*: yellow or reddish globules of molten sulphur, *sulphur*, *sulphides*.

(3). If it give off a gas, these conclusions may be drawn:

Oxygen, *chlorates*, *nitrates*, and *peroxides*; carbon monoxide, *oxalates*; carbon dioxide, *carbonates*; nitrogen peroxide, *nitrates*; ammonia, *ammonium salts*; sulphur dioxide, *sulphites*, *thiosulphates*; sulphuretted hydrogen, *sulphides*; hydrocyanic acid, *cyanides*; chlorine, *hypochlorites*; chlorine peroxide, *chlorates*. The gases are identified by their properties and reactions.

Warm a little of the substance in a dry test tube with strong sulphuric acid, and note if a gas be given off. The following conclusions can be drawn according to the nature of the gas:

Sulphur dioxide, *sulphites*, *thiosulphates*; sulphuretted hydrogen, *sulphides*; hydrocyanic acid, *cyanides*; oxygen, *chromates*, *peroxides*, *permanganates*; carbon dioxide, *carbonates*; carbon monoxide, *oxalates*, *formates*, *ferrocyanides*; chlorine, *hypochlorites*; chlorine peroxide, *chlorates*; hydrochloric acid, *chlorides*.

It is often stated that sulphuric acid acts in this manner in virtue of its strength. Being a "stronger acid" than, say, sulphurous acid, it is said to be capable of turning this latter acid out of its combination with a metal such as sodium, forming sodium sulphate, and liberating sulphur dioxide gas. This is not correct. Sulphuric acid is certainly one of the "strongest" acids, but it is not in virtue of its "strength" that it acts in the manner above described, but because it is more stable, and less volatile than sulphurous acid. Sulphuric acid is itself turned out of combination by the "weaker" but less volatile phosphoric acid.

Flame Tests. A number of metallic salts impart to a colourless Bunsen flame a characteristic coloration. It is necessary that the salts should be volatile, and the reaction is usually carried out by moistening a little of the solid substance with hydrochloric acid on a watch-glass, dipping a platinum wire into it, and holding the wire in the flame. The platinum wire must be thoroughly cleansed before use by repeatedly dipping into pure hydrochloric acid and holding in the flame until it no longer shows a reaction. The following is a list of the more characteristic colorations:

Sodium salts, yellow; *potassium* salts, violet; *barium* salts, pale green; *strontium* salts, bright crimson; *calcium* salts, dull red.

In addition to these a green colour is obtained with some *copper* and *manganese* salts.

Mere traces of these substances may be detected by using a spectroscope, which resolves the light into a number of coloured bands, the position and intensity of each being characteristic of the substance under examination.

The Blowpipe. For blowpipe analysis the student should be provided with an ordinary mouth blowpipe [13], in the use of which he will require some little practice before he is able to handle it properly. The airholes of the burner should be closed, so that a small luminous flame is obtained. The nozzle of the blowpipe is placed in the centre of the flame, resting on the top of the burner, and, on blowing steadily, a long, pointed, non-luminous, very hot flame will be produced. The flame consists of two zones—an outer, almost colourless at the tip, termed the *oxidising* flame, and an inner, or blue zone, termed the *reducing* flame. For an explanation of the terms oxidation and reduction, see page 1295. A little of the substance to be tested is mixed with carbonate of soda, and placed in a small hollow in a lump of charcoal. The reducing flame of the blowpipe is then directed on to it, with the result that if *silver*, *lead*, *bismuth*, or *antimony* be present, tiny globules, or beads, of these metals will be produced. If a little potassium cyanide be mixed with the potassium carbonate, *tin* and *copper* salts will also be reduced to metallic beads. *Iron* is also reduced to a metal by this treatment, but the temperature is not high enough to fuse it The resulting metallic powder is magnetic. The same applies to *nickel* and *cobalt*. The salts of *zinc* and *cadmium* yield in each case the corresponding oxide, which is white in the case of *zinc*, and brown in the case of *cadmium* If compounds of *zinc*, *aluminium*, and *magnesium* be first heated on charcoal in the blowpipe flame, and then moistened with a solution of cobalt chloride, and finally reheated, the mass turns green in the case of *zinc* compounds, blue with *aluminium*, and pale pink with *magnesium* Certain *phosphates* also give a blue colour.

Borax Beads. If the end of a piece of platinum wire be bent into a small loop, heated in the flame, and dipped into powdered borax, a little of the latter will adhere to the wire, and may be fused to a colourless bead in the blowpipe flame. Small quantities of metallic salts impart the following characteristic colours to these beads when reheated:

Blue, *cobalt* and *copper*; green, *chromium*; yellow, *iron*; amethyst colour, *manganese*.

Theory of Solution. Most of the tests we have so far considered belong to the class of "dry reactions." In the systematic examinations we depend on "wet reactions"—that is to say, tests made with *solutions* both of the "reagent" and the substance to be tested. It will be as well before proceeding with the systematic examination to consider the form in which substances exist in solution, and the chemical mechanism involving the formation of a precipitate, in order that what follows may be better understood. All substances belong to one of two classes—they are either crystalloids or colloids, although a substance can appear in both forms. [See PHYSICS.] The wet reactions we are about to consider apply only to crystalloids. If a substance appear in a colloided form (silica, some metallic sulphides, hydroxides of iron and aluminium and other

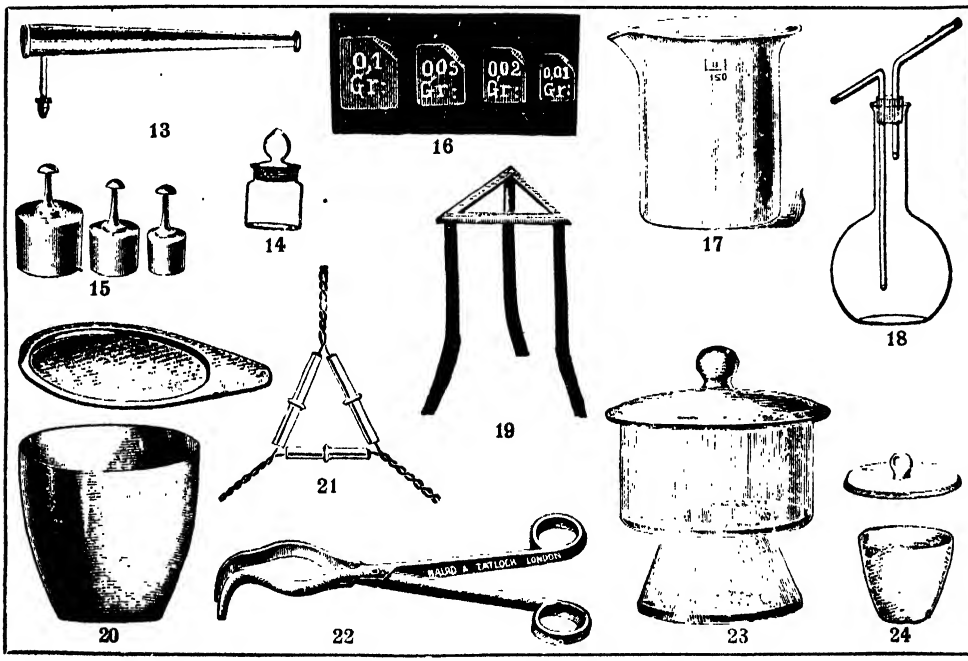
bodies have this tendency) we must treat it in such a manner as to alter its condition [see Analysis of Silicates], because only crystalloids form true solutions.

Acids, bases, and metallic salts, when dissolved in water, are more or less split up (dissociated) into their components (ions), and it is by an interchange of ions that precipitates are formed. Berzelius, the Swedish chemist, originated a dual theory of the constitution of chemical substances; but since his day the dual theory has been considerably modified, and the modern theory of electrolytic dissociation explains in a truly marvellous manner the numerous chemical reactions with which we have to deal. It will suffice if we confine ourselves to the following essentials, leaving out all reference to electrolysis and kindred subjects.

It will be noticed that the kation hydrogen is characteristic of the acids, and the anion hydroxyl of the bases. On mixing together an acid and a base in solution the hydrogen of the acid combines with the hydroxyl of the base to form water $H + OH \rightarrow H_2O$, which is not dissociated (or so slightly so that we can leave it out of account). There is left the anion of the acid and the kation of the base. In other words, we have now in solution a salt, thus:

$$\overset{+}{H}\overset{-}{Cl} \text{ and } \overset{+}{K}\overset{-}{OH} \text{ yield } H_2O \text{ and } \overset{+}{K}\overset{-}{Cl}.$$

Possibly the salt is only slightly soluble in water (no substances are absolutely insoluble in water) in which case it separates out—that is, a precipitate is formed. What happens is that the ions composing the insoluble salt cannot exist together in the free state, or only in very



APPARATUS USED IN CHEMICAL ANALYSIS

13. Mouth blowpipe **14.** Weighing bottle **15.** Brass weights **16.** Platinum weights **17.** Beaker **18.** Wash bottle **19.** Tripod **20.** Platinum crucible and cover **21.** Pipeclay triangle **22.** Crucible tongs **23.** Desiccator **24.** Porcelain crucible

Acids, Bases, and Salts. For our purpose we may regard these three types as composed of two ions, a positive or *kation* (metals including hydrogen and metal-like radicals, such as ammonium, NH_4), and a negative ion or *anion* (non-metals including the hydroxyl OH, the halogens and the acid radicals SO_4, NO_3, CO_3, etc.). Using the signs + (plus) for kation, and – (minus) for anion, the state of some of the commoner salts, acids, and bases in solution may be written graphically as follows:

$$\overset{+}{H} - \overset{-}{Cl},\quad \overset{+}{H} - \overset{-}{NO_3},\quad \overset{+}{HH} - \overset{-}{SO_4},\quad \overset{+}{HH} - \overset{-}{CO_3}.$$

$$\overset{+}{K} - \overset{-}{OH},\quad \overset{+}{NH_4} - \overset{-}{OH},\quad \overset{+}{Ca} - \overset{--}{OHOH}.$$

$$\overset{+}{K} - \overset{-}{Cl},\quad \overset{+}{KK} - \overset{-}{SO_4},\quad \overset{+}{NH_4} - \overset{-}{NO_3},\quad \overset{+}{Ca} - \overset{-}{SO_4}.$$

dilute solution; most of them combine, and, as the combination happens to be insoluble in water, the substance is precipitated. Such an occurrence is, however, much more commonly met with in mixing solutions of two salts together. In the mixed solutions we shall have four ions, and if by combination of two of them an insoluble substance is possible, it will be promptly formed, and a precipitate will appear. We may represent the two cases graphically as follows:

$$\overset{+}{H}\overset{-}{Cl} \text{ \& } \overset{+}{Ag}\overset{-}{NO_3} \text{ give } AgCl \text{ (precipitate) \& } \overset{+}{H}\overset{-}{NO_3}.$$

$$\overset{+}{K}\overset{-}{Cl} \text{ \& } \overset{+}{Ag}\overset{-}{NO_3} \text{ give } AgCl \text{ (precipitate) \& } \overset{+}{K}\overset{-}{NO_3}.$$

Mixtures of Soluble Salts. If on mixing solutions of two salts, say, potassium chloride and sodium sulphate—all possible

combinations are soluble in water—no precipitate will be formed; but if we concentrate the mixed solutions by evaporating off the water, a point will be reached when one of the salts will begin to separate out. This may be any one of the four following: Potassium chloride, sodium sulphate, sodium chloride, or potassium sulphate. It will depend entirely on which is the most insoluble in the solution at the temperature of the liquid. *This most insoluble salt will separate out*, whether it be one of those originally added or not.

It is evident that there is no object to be gained by asking which of the four salts were originally in solution. They were all there potentially

Degree of Dissociation. A salt is not, however, wholly dissociated, except in an infinitely dilute solution, so that both molecules of the salts as well as ions are present in the mixed solutions.

Strong acids, bases, and the salts prepared from them, are the most completely dissociated of substances in solution. Indeed, the strength of acids and bases will be proportional to the number of free hydrogen and hydroxyl ions respectively. Thus, solutions of acids of strengths proportional to their molecular weights will contain a larger or smaller number of hydrogen ions according to the strength of the acid, and anything that tends to reduce the proportion of hydrogen ions will reduce the strength of the acid. So, for instance, sulphuretted hydrogen gives no precipitate with zinc chloride in the presence of hydrochloric acid; but, if an excess of sodium acetate be added, a precipitate is formed, because the concentration of the hydrogen ion, or hydrion, is reduced. First, acetic acid replaces hydrochloric acid, and, being a weaker acid, there is a smaller proportion of hydrogen ions; and, secondly, the excess of sodium acetate still further reduces the degree of the dissociation of the acetic acid, and a liquid is obtained, which for all practical purposes is neutral. Yet, note, this result has been obtained, not by adding a base to neutralise the acid, but by merely adding an excess of a *neutral salt* - sodium acetate.

The All-important Ion. It is of the greatest importance for the student to realise that the properties of "electrolytes" (acids, salts, and bases) are the properties of the ions. It is the *ions* that react; consequently, the behaviour of the substance depends upon the nature and the number present. This fact simplifies very much the problems of analysis. We have not to learn the properties of the salts but merely of their ions. The ion chlorine will always combine with the silver ion to give a precipitate of silver chloride, whether derived from hydrochloric acid, potassium chloride, or any other soluble salt. On the other hand, no precipitate of silver chloride is obtained, say with potassium chlorate ($KClO_3$), because it does not contain the chlorine ion, but the chlorate ion (ClO_3). Examples of this sort could be multiplied indefinitely. It was formerly the custom to regard potassium platinochloride—the precipitate obtained from potassium chloride—as a double salt ($2KCl, PtCl_4$), yet it contains no chlorine ion, and does not yield silver chloride with silver nitrate solution, but rather the silver salt of chloroplatinic acid (H_2PtCl_6), dissociated thus $\overset{+}{H}\overset{+}{H}\ \overset{-}{PtCl_6}$.

Our systematic examination will therefore comprise the reactions of the ions. As the old nomenclature is that still generally used, we shall still adhere to it; thus, for instance, we shall speak of tests for chlorides instead of chlorine ions, for chlorates and not (ClO_3) ions, and for salts of silver, mercury, and lead, and not silver, mercury, and lead ions. Professor Ostwald has written a treatise on analytical chemistry, mostly from the theoretical standpoint, in which the theory of electrolytic dissociation is employed systematically throughout. The student is referred to this for full information on the subject. He will find it most interesting reading.

SYSTEMATIC EXAMINATION

The metals are conveniently divided into five groups. We give below the group reagent and a confirmatory test for each metal.

Group 1. *Silver, mercury (mercurous)* and *lead* salts. All these metals give white precipitates of the chlorides with hydrochloric acid. We have already noted the properties of these precipitates. As confirmatory tests: *silver*—sodium hydroxide produces a light brown precipitate of silver oxide (Ag_2O); *mercury*—sulphuretted hydrogen produces a black precipitate of mercury and mercurous sulphide; *lead* potassium iodide produces a bright yellow precipitate of lead iodide (PbI_2).

Group 2. Where no precipitate was formed on adding hydrochloric acid, or the precipitate, if formed, has been filtered off, the addition of sulphuretted hydrogen to the clear solution precipitates as sulphides:

Mercury (mercuric), lead, bismuth, cadmium, arsenic, antimony, and *tin*. As the sulphides of these metals are differently coloured, the precipitate formed will help the student to distinguish between them. If the sulphuretted hydrogen be added very gradually, the precipitate with *mercuric* salts is at first whitish, then changes rapidly from red and brown to black. *Lead, bismuth*, and *copper* form black precipitates (PbS, Bi_2S_3, CuS); *cadmium*, bright yellow (CdS); *tin* (*stannous*), dark brown (SnS); *stannic*, yellow (SnS_2); *antimony*, orange (Sb_2S_3); *arsenic*, yellow (As_2S_3). Sulphides of the last three metals differ from the preceding ones, as they are soluble on warming gently in ammonium sulphide solution. If *lead* has been present in quantity it will already have been detected in Group 1.

Confirmatory Tests. *Mercury (Mercuric)*: potassium iodide produces a bright red precipitate of mercuric iodide (HgI_2). Strong solutions of *bismuth* salts, when diluted with much water, produce white precipitates, owing to the formation of basic salts. Thus, bismuth chloride yields bismuth oxychloride ($BiCl_3 \rightarrow BiOCl$).

This reaction may be thus represented:

$$BiCl_3 + H_2O \rightleftarrows BiOCl + 2HCl.$$

The double arrows are intended to show that the reaction may take place in either direction. The proportion of $BiCl_3$ (soluble) to BiOCl (precipitate) will depend entirely on the proportions of hydrochloric acid and water.

The group BiO plays the part of a metal, and the chloride may be contrasted with silver chloride, thus: (BiO)Cl and AgCl.

Copper: a piece of iron, such as the blade of a penknife, dipped into a solution of copper salt becomes coated with a red deposit of metallic copper.

Tin (stannous): a solution of mercuric chloride, produces at first a white precipitate of mercurous chloride (Hg_2Cl_2), which, on warming with an excess of tin salt, turns grey, owing to the formation of metallic mercury. The reactions are thus represented:

$$2HgCl_2 + SnCl_2 = Hg_2Cl_2 + SnCl_4$$
$$Hg_2Cl_2 + SnCl_2 = Hg_2 + SnCl_4$$

Antimony and arsenic: very minute traces of these metals may be detected by means of Marsh's test. A current of hydrogen gas is produced by allowing a dilute solution of sulphuric acid to act on *pure* zinc, to which a drop or two of platinum chloride has been added, to promote by galvanic action the evolution of the gas, which is led through a narrow glass tube. When the hydrogen has expelled all the air from the apparatus, the gas is lit at the end of the tube, and a small quantity of the test solution is then added to the flask. The flame becomes coloured, as it carries with it the gases AsH_3 or SbH_3, and, on holding a cold porcelain basin to it, a metallic deposit of arsenic or antimony will be formed. A black stain indicates the presence of *antimony*, and a brownish and shiny mirror, *arsenic*. If this deposit be treated with a little sodium hypochlorite solution the *arsenic* stain will be rapidly dissolved, whereas the *antimony* stain will be unaffected. By heating the tube through which the gases pass with a flame, a metallic deposit is formed on the walls, and is further from the flame in the case of arsenic than with antimony.

The hydrogen gas should always be tested before starting the experiment to see that it is pure and free from arsenuretted hydrogen (AsH_3), as arsenic is a common impurity in zinc. Marsh's test can also be applied to organic substances suspected to contain arsenic, and thousands of these tests were made after the cases of arsenic poisoning from beer a few years ago. This test is also one commonly employed in detecting minute traces of arsenic or antimony in the viscera in post-mortem examinations of persons suspected of having been poisoned.

Group 3. This group may be separated into two subdivisions. The first of these comprises the metals *iron, aluminium,* and *chromium,* which are precipitated on adding to a fresh solution of the substance to be examined an excess of ammonium chloride followed by ammonia.

In the case of iron (*ferrous salts*), the precipitate is whitish to dark green ($Fe(OH)_2$). In the case of *ferric* salts, foxy red in colour ($Fe_2(OH)_6$); *aluminium* is precipitated white as aluminium hydroxide ($Al_2(OH)_6$). Chromium is only partially precipitated. All these precipitates consist of hydroxides of the metals. If no precipitate is formed, add a little ammonium sulphide, when precipitates will be formed of *zinc sulphide* (ZnS) (white); *manganese sulphide* (MnS), (flesh coloured); *chromium hydroxide* ($Cr_2(OH)_6$) —not the sulphide—(bluish green), *nickel* and *cobalt sulphides* (NiS and CoS) (black).

Confirmatory Tests. *Iron (ferrous)*: potassium ferro-cyanide produces a white precipitate ($K_2Fe_2(CN)_6$), which turns blue on shaking in the air through oxidation to Prussian blue.

Iron (ferric) salts; potassium ferrocyanide produces a dark blue precipitate, Prussian blue. At first, the idea of testing for an iron salt with another compound of iron may seem strange; but it is easily explained when we remember that the iron salts in question contain ferric ions, while potassium ferrocyanide contains another and more complex ion ($Fe(CN)_6$), which, of course, reacts as a whole, and has different properties to the ferric ion.

Aluminium: ammonium sulphide produces a white flocculent precipitate of aluminium hydroxide ($Al_2(OH)_6$), the sulphide possibly first formed being decomposed.

Zinc: sodium hydroxide produces a white precipitate ($Zn(OH)_2$), soluble in excess. Some of the best confirmatory tests for metals of this group have been given under Blowpipe Analysis.

Group 4. This comprises three metals—*barium, strontium,* and *calcium*—all of which are precipitated as carbonates on adding ammonium carbonate solution to the liquid to which ammonia and ammonium chloride have already been added. In all cases the carbonates are white precipitates. ($BaCO_3$, $SrCO_3$, and $CaCO_3$)

Confirmatory Tests. *Barium:* potassium chromate produces a yellow precipitate of barium chromate ($BaCrO_4$), while calcium sulphate ($CaSO_4$) produces a white precipitate of barium sulphate ($BaSO_4$). *Strontium:* potassium chromate produces a yellow precipitate in concentrated solutions only, while calcium sulphate produces a white precipitate of strontium sulphate ($SrSO_4$) on standing (the strontium sulphate is formed in solution immediately on adding a soluble sulphate, but does not begin to separate out at once from dilute solutions owing to the phenomena of "supersaturation"). *Calcium:* ammonium oxalate produces a white precipitate of calcium oxalate (CaC_2O_4), insoluble in acetic acid.

Group 5. We now come to the metals which are not precipitated by any of the foregoing reagents. They differ from those already considered in that most of their salts (including carbonates) are soluble in water. Metals of this group comprise magnesium, potassium, ammonium, and sodium. *Magnesium* differs from the others in that it forms an insoluble phosphate. A solution of magnesia salt, containing ammonia

and ammonium chloride gives a white crystalline precipitate with sodium phosphate. This precipitate consists of magnesium ammonium phosphate ($MgNH_4PO_4$), and as it is slightly soluble in water it does not separate very rapidly from dilute solutions (supersaturation). The contents of the test tube should be shaken vigorously, or the sides of the test tube rubbed with a glass rod to induce formation of the precipitate.

Confirmatory Tests. To a solution of a *potassium* salt add one of platinic chloride, and stir well with a glass rod; a yellow precipitate (K_2PtCl_6) separates out. All *ammonium* salts smell of ammonia gas when warmed with alkalies. *Sodium:* there is hardly a sodium salt which is not readily soluble in water, so that for all practical purposes we may say that sodium salts give no precipitates with reagents.

The flame tests already mentioned will be found useful in testing for the metals of this group and the preceding one.

EXAMINATION FOR ACIDS

Besides the preliminary tests already described there are a number of wet reactions for acids of which we give below the more important. These tests apply to salts of the acids in question, and generally to the free acids as well. We can subdivide them into groups as in the case of the metals.

Group 1. This group comprises *sulphuric acid* and *hydrofluosilicic acid*. The latter is very seldom met with. These acids and their salts, with barium chloride solution, give white precipitates (such as barium sulphate, $BaSO_4$), which are insoluble in hydrochloric acid, so that the precipitate may be formed in the presence of hydrochloric acid, or it may be added subsequently, when it will be noticed that the precipitate will not dissolve.

Group 2. This group comprises acids which are precipitated by barium chloride, but these precipitates are soluble in hydrochloric acid, so that acid added to the precipitate rapidly dissolves it. The group includes the acids *carbonic, oxalic, boric, phosphoric, hydrofluoric, arsenious, arsenic, sulphurous, thiosulphuric, chromic,* and *iodic*.

Confirmatory Tests. The student should note that when he applies a reagent and makes himself acquainted with a test, he is learning at the same time a test for the reagent. Thus, we have explained how calcium salts can be tested for by means of a solution of ammonium oxalate. *Oxalates* can equally well be tested for with a solution of calcium salt. Thus in testing for an oxalate it is necessary merely to add calcium chloride to a neutral solution, when we obtain a precipitate of calcium oxalate whose properties we have already described.

Boric acid: a piece of tumeric paper is dipped into a solution of a borate, such as common borax, acidified with hydrochloric acid, and afterwards dried. Boric acid is indicated by a red-brown colour.

Phosphoric acid: a solution of ammonium molybdate in the presence of excess of nitric acid gives a yellow precipitate on warming gently. Very little of the substance and an excess of ammonium molybdate solution should be taken. The test is a delicate one.

Hydrofluoric acid: heat a little of the dry substance in strong sulphuric acid, when hydrofluoric acid (HF) is evolved. The liquid in the test tube shows a characteristic oily appearance. If the reaction be carried on in a platinum crucible covered with a piece of glass, the glass will be etched by the action of the acid vapours.

Arsenious and *arsenic acids:* solutions of acids must be first carefully neutralised with a little ammonia, when, on adding silver nitrate, a yellow precipitate of silver arsenite (Ag_3AsO_3) will be formed with the former, and a brown with the latter acid (silver arsenite, Ag_3AsO_4).

Sulphurous acid: nothing is more characteristic than the smell of the gas when driven off on warming the solution with a little mineral acid. It has, moreover, the power of turning a red solution of potassium bichromate green (reduction to a chromium salt). The test may be performed by lowering a glass rod with a drop of the bichromate solution on the end into the test tube, avoiding touching the sides. On removing the rod a little later, the drop hanging from the rod will be seen to have turned green.

Thiosulphuric acid: mineral acids precipitate finely divided sulphur, while at the same time sulphur dioxide gas is given off.

Chromic acid: salts of this acid are well coloured. The precipitate with barium chloride is yellow. We may reverse the test for sulphurous acid, a little of which turns the yellow or red solution of the chromates green.

Iodic acid: iodates are decomposed on heating. The residue readily yields vapours of iodine on warming with strong sulphuric acid. These violet vapours are very characteristic of the element.

Group 3. Acids of Group 3 are precipitated by a solution of silver nitrate. We shall consider only those which are not precipitated by barium chloride. These comprise *hydrochloric, hydrobromic, hydriodic, hydrocyanic,* and *hydrosulphuric* acid. The precipitates, consisting of the silver salts, are white or yellow, with the exception of silver sulphide, which is black. Silver chloride we have noticed when testing for silver. The precipitate is insoluble in nitric acid, but soluble in ammonia solution.

Silver bromide is yellowish in colour. It is almost insoluble in nitric acid, but dissolves in strong ammonia solution.

Silver iodide is yellow, and differs from bromide in that it is very sparingly soluble in ammonia solution.

Silver cyanide, which is white, behaves almost exactly like silver chloride, but does not dissolve so readily in ammonia. It dissolves in excess of potassium cyanide giving $KAg(CN)_2$.

Confirmatory Tests. *Hydrochloric, hydrobromic,* and *hydriodic acids* may be identified by the liberation of the corresponding elements—chlorine, bromine, and iodine—by heating with sulphuric acid and a little powdered oxide of manganese. For the appearance and properties of these elements see page 1444.

Cyanides are decomposed by hydrochloric acid, with the liberation of hydrocyanic acid (HCN), which has a peculiar odour, said to resemble bitter almonds, but, as a matter of fact, its smell is characteristic and not exactly like anything else. As it is extremely poisonous, care must be taken not to inhale too much of it.

Group 4. This group comprises a few acids which are not precipitated by barium chloride or silver nitrate. They include *nitric*, *chloric*, and *perchloric acids*. *Nitric acid* is easily detected by its action on copper. Copper shavings are readily dissolved either by the free acid or by a mixture of a salt and a little sulphuric acid, with the evolution of brown vapours (oxides of nitrogen) and the formation of a blue solution (copper nitrate). Another very characteristic test is to mix the solution to be tested with a solution of ferrous sulphate. A little strong sulphuric acid is carefully poured down the side of the tube, so that it sinks and forms a layer underneath the aqueous solution. The test tube is held under the tap to cool it thoroughly, and on holding it up to the light a brown ring will be seen at the juncture of the two liquids. The action of the sulphuric acid on the nitric acid is to liberate oxides of nitrogen, which give a dark brown or black colour with ferrous salts.

Insoluble Substances. There are a number of insoluble substances which are very inert and require to be tested for carefully.

Although insoluble in water and acids, silica is dissolved to a certain extent on boiling with strong alkali solutions, or better still by fusing it with a mixture of equal weights of the carbonates of soda and potash (fusion mixture). The fused mass is dissolved in water and acidified, when gelatinous silica separates out either at once or on concentration of the solution.

We have omitted to mention all rare elements—some of which, however, are of considerable and increasing importance—as by doing so we should be introducing too many complications. For these the student must refer to larger works, specially devoted to the subject.

Tests for Organic Substances. There are a number of organic substances to which routine tests are applicable. One or two of the more important may be mentioned here.

Tartaric, citric, and *malic acids:* these acids, like oxalic acid, yield precipitates of the calcium salts—for instance, with calcium chloride in neutral solution.

Tartaric acid can be further identified by the fact that a strong solution shaken with potassium chloride gives a white crystalline precipitate of acid potassium tartrate.

Benzoic acid gives a yellow-brown precipitate with ferric chloride. The acid volatilised by heating in a tube emits a vapour of characteristic odour, which condenses again in the cooler parts of the tube.

Carbolic acid. Ferric chloride produces a violet colouration, but a similar colour is obtained with *salicylic acid.* These two substances are related, and a smell of carbolic acid is evolved on heating salicylic acid with lime.

QUANTITATIVE ANALYSIS

In our discussion of qualitative analysis we have given an outline of the methods of ascertaining the *nature* of a substance; in this section we shall show how to determine the *amount* in which it is present, whether by itself or in admixture with other substances.

This portion of our subject is divisible into two sections—analysis by weight, or *gravimetric* analysis, and by volume, or *volumetric* analysis. Volumes are also measured in the analysis of gases, but this is usually treated under gas analysis.

Gravimetric Analysis. "Gravimetric analysis has for its object to convert the known constituents of a substance into forms or combinations which will admit of the most exact determination of their weight, and of which, moreover, the composition is accurately known" (Fresenius). Thus, we shall suppose that one of the known constituents of a substance we are dealing with is sulphuric acid or a soluble sulphate, and that we require to determine (or estimate) its amount. We proceed to convert it into a substance of known composition, say the barium salt or barium sulphate, which can be separated and accurately weighed. As one equivalent of sulphuric acid will produce one equivalent of barium sulphate, we can calculate the amount of sulphuric acid present from the weight of the barium sulphate found. We have special reasons for choosing the barium and not some other salt such as the calcium salt. We have seen in our study of qualitative analysis that barium sulphate is very insoluble in water. It is, as a matter of fact, one of the most insoluble substances known, and consequently well adapted for our purpose.

Sulphuric Acid Estimation. We shall proceed to make an estimation of sulphuric acid. We may suppose that a careful qualitative analysis has already been carried through, and that the precipitate obtained with barium chloride solution in the presence of hydrochloric acid was fairly copious, pointing to a considerable proportion of sulphuric acid or sulphate present.

About one gramme of the substance is accurately weighed off on a chemical balance [see page 61]. Substances to be weighed must never be put directly on to the scale-pan, but are weighed on a watchglass [2] or in a weighing bottle [14], whose weights must first be determined and deducted from the total weight found.

Enter the weights in your book thus:

Weight of watchglass + substance	=	1·9472 gr.
Weight of watchglass	...	·8315 „
∴ Weight of substance taken for analysis	=	1·1157 „

The weights down to one gramme are made of brass [15]; below one gramme usually of platinum [16]. For weights less than a centigramme, the rider attachment situated over the beam of the balance is used.

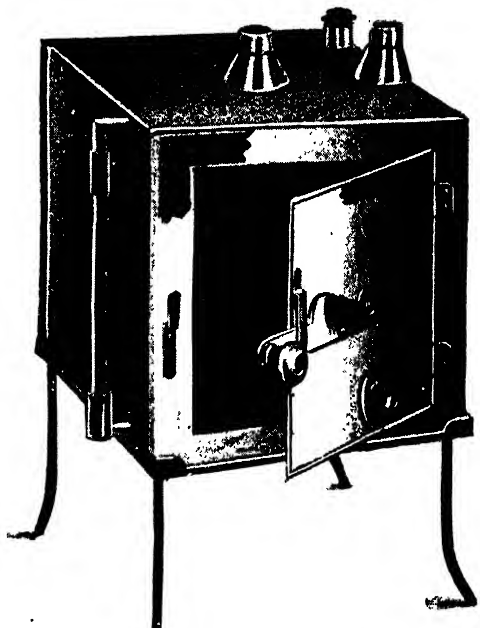
A weighing bottle should be employed if the substance to be tested is "hygroscopic"—that is to say, has the power of absorbing moisture from the air; otherwise a watchglass will usually be preferred.

Removal of Insoluble Matter. Having weighed out the substance, it is dissolved in pure (that is, distilled) water in a beaker [17]. Sometimes the water should be heated to get the substance dissolved more quickly. We assume here that it is soluble in water, or at any rate that we are estimating only the sulphuric acid in the soluble portion. If there be an insoluble portion, it should first be filtered off. For this purpose a circular filter paper is folded in four in the form of a quadrant [4], the flap opened and fitted into a glass funnel. The paper is then moistened with distilled water from a wash bottle [18] and fitted evenly against the sides of the funnel. The liquid is then poured down a glass rod into the funnel, which should not be filled above three-quarters the height of the filter paper. When the whole has run through, the beaker is washed out three times with water, the washings being poured through the filter paper so that the whole of the soluble matter is collected in a vessel, such as a beaker, placed under the funnel.

Precipitation as Barium Sulphate. Hydrochloric acid is added to the liquid, which should not more than half fill the beaker. It is heated to boiling on a tripod [19], and sufficient barium chloride solution added to precipitate the whole of the sulphuric acid as barium sulphate. For this purpose more than the theoretical quantity of $BaCl_2$ will be required. The liquid is kept boiling for a minute or two and the precipitate allowed to settle. When precipitated from a boiling solution, barium sulphate settles more rapidly and is easier to filter. Compare **11** and **12**; both are barium sulphate precipitates which have been standing together; **11** has been boiled and has rapidly settled, while **12**, precipitated in the cold, only just begins to show signs of settling. The clear, "supernatant" liquid is poured off through a close-grained filter paper. The "filtrate"—the liquid which passes through—should be boiled for a few minutes after adding two or three drops more barium chloride solution to make sure that the whole of the sulphuric acid has been precipitated. With the aid of a jet of hot water from a wash bottle [18] the precipitate is transferred from the beaker to the filter paper and washed further by means of a hot-water jet from the wash bottle until the filtrate is free from chloride (a few drops should give no cloudiness with silver nitrate solution).

Igniting the Precipitate. The filter paper is allowed to drain and is then transferred bodily with the precipitate to a previously-weighed platinum crucible [20] lying on a pipe-clay triangle [21] on a tripod [19]. Care must be taken not to tear the paper or lose any of the precipitate. The lid is placed on the crucible, and a Bunsen burner [3] with full flame set underneath. There is just a little spluttering at first; the lid is then removed, the crucible tilted a little to one side, and the paper charred and eventually burnt off to a white ash. After heating to redness for a short time, nothing but a small quantity of white substance—sulphate of barium and filter paper ash—remains at the bottom of the crucible. Any dark portions left point to unburnt carbon from the paper. As the carbonaceous matter is liable to reduce the barium sulphate into sulphide, it is moistened when cold with a drop of nitric acid to convert any sulphide into sulphate, reheated, cooled, and weighed.

Weighing and Calculating. For most purposes the weight of the ash may be neglected or allowed for and deducted from the weight of the precipitate if great accuracy be insisted on. Packets of pure filter paper for quantitative work generally have marked on them the average weight of the ash. The crucible is lifted off the triangle by means of a pair of crucible tongs [22], best made of nickel, and deposited in a desiccator [23] to cool. The desiccator consists of a glass jar with cover having strong sulphuric acid or calcium chloride at the bottom so that, the air above being dry,



25. STEAM DRYING OVEN

the crucible and contents cool without absorbing moisture and increasing in weight. The crucible and contents are then weighed.

Enter the results in your notebook thus:

Weight of crucible + barium sulphate	= 19·4377 gr.
Weight of crucible	= 18·4312 ,,
∴ Weight of barium sulphate	= 1·0065 ,,

This quantity of barium sulphate is equivalent to $1{\cdot}0065 \times \frac{80}{233} = {\cdot}3456$ gm. (SO_3);

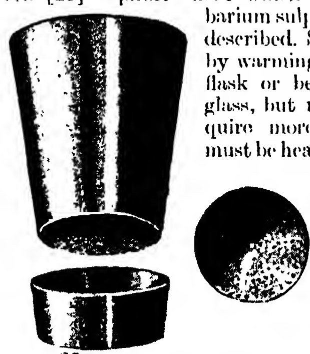
or, expressed in percentages:

$$\frac{{\cdot}3456}{1{\cdot}1157} \times 100 = 30{\cdot}9 \text{ per cent.}$$

In the foregoing we chose the estimation of sulphuric acid, and have given a full description of the chemical manipulations, as it is a determination which has to be made in the technical laboratory as often as any other. Moreover, if

is the universal method for the determination of sulphates. No satisfactory volumetric method has been devised. Of course, this does not apply to solutions of the free acid.

Analyses of Other Substances. We are unable in the short space at our disposal to give specific instructions as to the carrying out of other gravimetric estimations, and must content ourselves with mentioning a few points in which modifications of the above method are necessary or convenient. Platinum crucibles [20] cannot always be used, as some substances, such as compounds of lead, attack and alloy with the platinum. In these cases a porcelain crucible [24] should be taken. As instances where this is necessary, we may mention: *lead*, as lead carbonate ($PbCO_3$) precipitated from solutions of lead salts by ammonium carbonate in presence of a small quantity of ammonia; *zinc*, as zinc carbonate ($ZnCO_3$) precipitated with sodium carbonate; *silver*, as silver chloride ($AgCl$) precipitated with hydrochloric acid. The precipitates in such cases as these cannot be put wet into the crucible, but must first be dried in a steam oven [25] and the dry precipitate separated as much as possible from the filter paper and ignited apart from the latter in the crucible. This operation should be performed with the crucible standing on a piece of glazed paper. The precipitate may be detached by the aid of the clean blade of a penknife, and any substance spilt on the paper may be afterwards swept into the crucible with a camelhair brush. The filter paper is folded up and securely held by wrapping a long piece of platinum wire round it; the end of the wire is fused into a glass handle. The paper is burnt in the cage of wire formed in this manner and the ash is allowed to drop into the crucible containing the already ignited precipitate, so that all are weighed together.



26. GOOCH CRUCIBLE

The Gooch Crucible. The method just described is somewhat tedious, and unless the greatest care be taken, some of the precipitate is sure to be lost. Such determinations as those of silver and chlorine are rapidly made in a Gooch crucible [26]. It consists of a platinum crucible the base of which is perforated with numerous small holes; it fits into a filtering flask similar to that shown [27]. Some short-fibred asbestos thoroughly extracted with acids is poured into the crucible, and as the water drains away it leaves a plug of fibre on the bottom. This is then covered with the perforated plate seen on the right of the illustration [26], and on connecting the flask with an exhaust pump, most of the water is sucked out and fresh water may be drawn through, so that the asbestos is thoroughly washed. The crucible is then detached, dried in an air oven at 110° C., and weighed. The silver chloride is precipitated in the ordinary manner, and the liquid poured into the crucible. The aqueous liquor is sucked through into the filtering flask and the precipitate left entangled in the asbestos. It is washed with distilled water in the usual manner, after which the crucible is removed to the oven, dried and weighed. The difference in weight represents silver chloride. Results just as accurate are got by drying at 110° C. as when silver chloride is heated to fusing point. There is no need to put in fresh asbestos each time a determination is made, as the crucible can be used several times before the accumulation of precipitates necessitates cleaning it out.

More Important Estimations. We will indicate briefly the method of analysis in some instances not already treated of.

Iron and *aluminium*: precipitate as hydroxides with slight excess of ammonia and ignite wet.

Copper: precipitates as oxide with caustic potash or soda. If the liquid contain any organic matter it must be destroyed by concentrating in an open dish or basin [28], with the addition of soda and nitre, and then fusing, redissolving, and precipitating.

Sulphur, whether present as sulphides or free or contained in organic matter, must be oxidised with nitric acid to convert it into sulphuric acid which can then be estimated as barium sulphate in the manner already described. Sulphides are readily oxidised by warming with strong nitric acid in a flask or beaker covered with a clock-glass, but many organic substances require more drastic treatment. They must be heated with nitric acid to a high temperature—200° C. to 300° C.—and this can be accomplished only by sealing them up with nitric acid in a strong glass tube [29] (Carius method) and placing the tube in a special oven or furnace [34]. The latter illustration shows the ends of the oven raised and the iron tubes in which the glass ones are placed, so that no damage will be done should they burst—a thing which not infrequently happens, when they go off with a report, leaving nothing but a little powdered glass behind. In sealing the glass tubes care is taken to leave a fine capillary at the end [29] so that after a couple of hours, when the reaction is complete, the tubes are opened and the accumulated pressure released by fusing the end of the capillary without taking the glass tube out of the iron one. All danger is thus avoided. The pressure released, the tube is cut into halves and the contents washed out into a beaker and precipitated with barium chloride in the usual manner.

Chlorine in soluble salts may be precipitated directly with silver nitrate, but when contained in organic substances it must first be liberated in the form of chloride by heating with nitric acid in a sealed tube in the manner just described. A crystal or two of silver nitrate is put into the tube, so that on opening, the silver chloride has only to be washed out into a Gooch crucible and weighed.

Magnesium. Soluble salts are heated with ammonium chloride, and made very slightly

alkaline with ammonia. An excess of sodium phosphate is added, and the liquid is stirred for a minute or two. When the precipitate has formed, add more strong ammonia, and put aside to stand till the next day. Filter off, wash with ammonia solution (1 in 12), and ignite. The precipitate of magnesium ammonium ($MgNH_4PO_4$ $6H_2O$) is converted by ignition into magnesium pyrophosphate ($Mg_2P_2O_7$), in which form it is weighed, all the volatile water and ammonia being driven off.

Phosphates may be estimated by the above process for magnesium.

Antimony may be estimated by precipitating it from an acid solution as the sulphide (Sb_2S_3) by saturating with sulphuretted hydrogen gas. Strong solutions of antimony chloride are precipitated on dilution with water; tartaric acid added to the liquid prevents this. There are certain difficulties in the way of weighing sulphide of antimony, as it decomposes when heated in air. It must either be dried by heating in hydrogen gas (which can be conveniently carried out in a Gooch) or else oxidised with nitric acid, which converts it into the oxide (Sb_2O_3). This is then ignited and weighed.

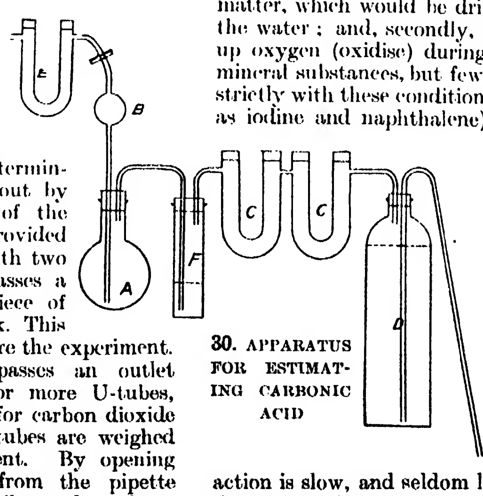
28. PORCELAIN BASIN

Arsenic is precipitated as sulphide (As_2S_3), collected in a Gooch, and dried at 100° C.

Tin is also precipitated as sulphide, and on igniting is converted into the oxide (SnO_2), in which form it is weighed.

Mercury is precipitated as sulphide (HgS), collected in a Gooch, dried at 100° C., and weighed.

Carbonates. As carbonic acid is widely distributed both as a constituent of the atmosphere and as a component of minerals, its estimation is a matter of considerable importance. Besides the methods already given, there are others depending on the decomposition of carbonates and the measurement of the gas evolved either by weight or by volume. The determination by weight is carried out by placing a weighed amount of the substance in a flask [A, 30] provided with a rubber cork pierced with two holes. Through one hole passes a pipette, B, closed with a piece of rubber tubing and a pinch cock. This pipette is filled with acid before the experiment. Through the other hole passes an outlet tube connected with two or more U-tubes, C C, filled with an absorbent for carbon dioxide such as soda lime. These tubes are weighed before starting the experiment. By opening the pinch cock, the acid from the pipette (this must be a non-volatile acid such as sulphuric) is allowed to enter the flask in small quantities at a time, so that the carbon dioxide is given off in a slow stream, and is absorbed by the soda lime. The second U-tube should remain cool, showing that practically all the gas is absorbed in the first one. When the action is complete, the carbon dioxide remaining in the flask is drawn into the U-tubes by the aspirator D. The air drawn through the flask should be freed from carbon dioxide by passing it through the soda lime tube, E, and a wash bottle, F, containing strong sulphuric acid to retain moisture, should be interposed between A and C. The U-tubes, C C, are reweighed, and the increase in weight represents carbon dioxide.



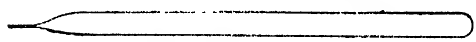
30. APPARATUS FOR ESTIMATING CARBONIC ACID

27. FLASK FOR FILTERING UNDER PRESSURE

If the flask A be removed so that the soda lime tube be open to the atmosphere, and a definite volume of air be sucked through the tubes by running out and measuring the water from D, we have an apparatus for estimating the amount of carbon dioxide gas in the atmosphere.

Measuring Moisture. Moisture has frequently to be measured, as substances which have been exposed to the air are never dry. The simplest method is to place a weighed quantity of the substance in an open dish, watch or clock glass, also previously weighed. Then heat in an oven [25] at 100° C., or a little higher, till the substance ceases to lose weight. The loss of weight will give the moisture or water contained in the substance.

This method is simple and accurate, provided,



29. CARIUS TUBE

first, that the substance contains no other volatile matter, which would be driven off and lost with the water; and, secondly, that it does not take up oxygen (oxidise) during the heating. Most mineral substances, but few organic ones, comply strictly with these conditions. Some bodies (such as iodine and naphthalene) are far too volatile to admit of treatment in this manner, while others, such as rosin, are only slightly volatile, so that the results are good enough for most purposes, although not strictly accurate. Oils oxidise and increase in weight, as also do substances such as wood pulp, but the action is slow, and seldom leads to serious error. Sometimes the moisture in mineral substances is held very firmly (water of constitution), and a much higher temperature than 100° C. is required to drive it off. The same principle can be made use of as already described,

but the watchglass must be replaced by a crucible, and the temperature, if necessary, raised to a red heat. Unfortunately, the substance frequently suffers other chemical changes at these high temperatures, so that in many cases the water cannot be estimated by difference. In such cases the substance is heated in a hard-glass tube, and the moisture drawn over weighed U-tubes containing calcium chloride, the water being directly estimated, as in the case of carbon dioxide absorbed in soda lime.

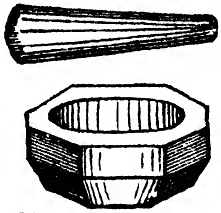
Silicious Materials. The analyst is frequently called upon to examine substances such as cement, clay, fireclay, and firebrick, silicious limestones and dolomites, sand, iron ores, slags, and numerous other substances containing silica, and we shall now consider the best methods in such cases.

Some substances, such as iron ores, limestone, lime, magnesite, dolomites, and cement are decomposed on repeated treatment with strong hydrochloric acid to which a few drops of nitric acid have been added, leaving a residue consisting of silica. A portion of this tends to remain in solution, owing to the persistency of the colloidal state, and is rendered insoluble only by

33. GLASS BLOWPIPE

evaporating down the mixture in a porcelain dish and heating the dry residue for half an hour at about 150° C. The "baked" mass is then treated with a small quantity of strong hydrochloric acid, stirred up with a glass rod, and the insoluble silica filtered off and washed with hot water. The residue may be ignited straight away and weighed as described for barium sulphate. The solution contains iron, aluminium, calcium, magnesium, etc., as chlorides, which may be estimated by methods already described. Of course, the iron and alumina must be first precipitated, and the filtrate carefully preserved, as this will contain calcium and magnesium. The calcium is precipitated as oxalate, and the magnesium estimated in the filtrate.

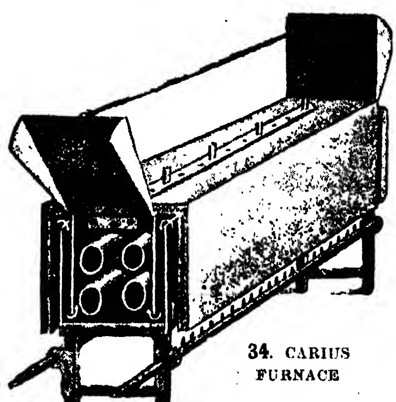
Analysis by Fusion with Alkali. In the case of many silicious substances the decomposition with acids is not sufficiently complete for analytical purposes. This applies to some of the substances mentioned in the preceding paragraph —cement, for instance—although for many purposes the acid treatment gives good enough results, and is, besides, a rapid method. It cannot, however, be used where an exact analysis is required. In either case, the substance to be analysed must be very finely powdered, not always an easy matter. Some substances when they come to hand are already in a finely divided state, as clay and cement; but a portion from which the sample for analysis is to be taken should always be reground in an agate mortar [31] to reduce larger particles which



31. AGATE MORTAR

32. STEEL MORTAR

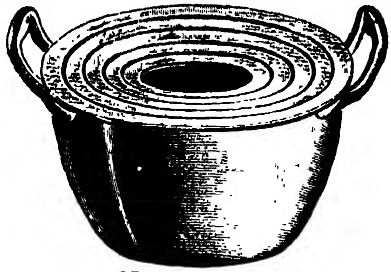
are always present. Iron ores are often very hard, and must first be crushed in a steel mortar [32], and then powdered in the agate mortar. Weigh out accurately about one gramme of the material into a capacious platinum crucible [20], and add about eight grammes of the mixture of equal parts of pure dry carbonates of sodium and potassium— "fusion mixture"—which has a lower melting point than either carbonate by itself. Mix thoroughly with a glass rod, cover with the lid, and heat on a clay triangle, first with a small flame, and then gradually increasing its size until the gas is full on, finally heating for a quarter of an hour over a blowpipe flame. The mouth blowpipe will not do; you will want a gas blowpipe [33] fitted with foot blowers [37]. The contents of the crucible should be at a bright red heat and in a state of gentle fusion. Take the crucible firmly in a pair of tongs, and while still red hot plunge it to about half its height into a basin of cold water. This cools the "melt" rapidly, so that on solidifying it usually cracks away from the sides, and is easily removed. Place the crucible on its side in a deep porcelain dish, cover with water, and gently warm on a water bath [35] till the contents come away, when the crucible is removed, and rinsed with a jet of water so as to retain everything in the dish. Cover the dish with a clock-glass and run



34. CARIUS FURNACE

in hydrochloric acid very carefully down the lip of the dish. The addition of acid is continued, keeping the dish covered with the clock-glass all the while until effervescence ceases. In this

manner, particles of liquid spray are caught on the under surface of the clock-glass and drip back into the dish. The clock-glass should, of course, be placed convex side downwards. Remove it, and wash any drippings back into the dish, and continue heating on the water bath till the contents are dry, then place in the air oven and heat to 150° C. for half an hour, to render the silica insoluble, and continue the analysis exactly as before.

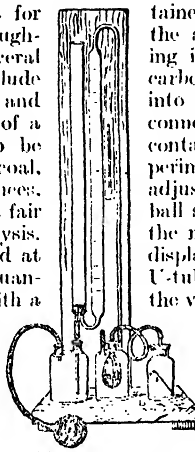


35. WATER BATH

Sampling. We have assumed that the portion of material selected for analysis is a representative sample of the whole. To ensure this, special precautions have to be taken, as most materials for analysis are by no means uniform throughout. Take, for instance, a delivery of several truckloads of coal. It will probably include material from different parts of the seam, and even if we analyse different portions of a single lump, it will not be found to be uniform throughout. In the case of coal, ores, clay, and numerous other substances, it is at least as important to procure a fair sample as to make an accurate analysis. Supposing the trucks are being unloaded at the works, the chemist removes small quantities, say a pound or two at a time, with a shovel or other suitable instrument, every now and again at some convenient point—say, where the material is being taken by an elevator to storing bins. These samples are thrown out on to an impervious floor and thorougly mixed and divided into four quarters or heaps. Two of the diagonally opposite heaps are removed, and the remaining two remixed, and again divided into four, and the process repeated. At a certain stage large lumps must be broken up, and the division repeated, until we are left with only a few pounds of lumps and powder, not larger, say, than walnuts. These are taken to the laboratory, crushed further in a mortar, and dividing operations repeated, with further grinding at suitable stages, until we are left with only a few grammes of the finely powdered material for analysis. If the process has been properly conducted, the sample, amounting to only a few grammes, will be fairly representative of several tons of the material which we started to examine.

The Calcimeter. In the cement industry and some others, rapid estimations of carbonates have to be frequently made, and for this purpose some form of calcimeter is generally used. In cement works it is necessary to make regular tests of the slurry [see page 1580] to ascertain the proportion of chalk it contains.

A small quantity of the slurry is dried, weighed, and introduced into the bottle shown on the right-hand side of the illustration [36]. This bottle is provided with a short tube, which rests against the side and holds rather more than sufficient acid to decompose the chalk contained in the slurry. On inclining the bottle, the acid flows out of the tube, and, coming into contact with the slurry, liberates carbon dioxide gas. This gas finds its way into the middle vessel, which stands in connection with a long graduated U-tube containing water. Before starting the experiment the levels of water in this tube are adjusted by means of the bottle and rubber ball seen on the left. The air driven out of the middle flask by the carbon dioxide gas displaces water in the graduated limb of the U-tube, and on adjusting the levels again the volume of carbon dioxide may be directly read off. A correction has to be made for the amount of gas absorbed by the acid in the bottle. Of course, this method is suitable only where rapid estimations are required, as the results are probably not correct to more than half of one per cent.



36. CALCIMETER

It is hoped that this short account of some of the more important analytical operations will give the reader an insight into the principles on which the science is based. He will, however, find a number of analytical processes described in the subsequent sections of Applied Chemistry, Kjedahl's nitrogen estimation under Glues and Adhesives, the analysis of nitrates and phosphates under Manures, and food and water analysis under the various food sections. The subject of volumetric analysis has been omitted as it could not be adequately dealt with in the space at our disposal. For further study we recommend the text-book of Clowes & Coleman, or the standard work on volumetric analysis by Sutton. Most of the illustrations in this article are from apparatus supplied by Messrs. Baird & Tatlock

37. FOOT BELLOWS

Continued

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CYCLOPÆDIA OF SHOPKEEPING

PHOTOGRAPHERS. The Studio and its Equipment. Finance of the Business. Varieties of Work. Copyright. Departments to Cultivate

PHOTOGRAPHIC DEALERS. The £100 Stock. Apparatus and Chemicals. The Dark-room. Side Lines. Prices and Profits

PHOTOGRAPHERS

For those who have an artistic taste, combined with a knowledge of the art of photography, professional photography offers good prospects. It is usual to decry photography as a business on account of the enormous number of amateur photographers which, it is imagined, spoils the field for the professional. Curiously enough, the number of persons who seriously practise photography as amateurs is comparatively small. The average amateur who possesses a camera does not turn out presentable work His friends gaze at his attempts and say, "Very well for an amateur," which is only another way of saying that the professional is not seriously rivalled by the amateur. If anything, the public learn, from seeing the productions of an amateur, that photography is not the simple art it appears to be at first sight. It is also a fact that amateur photographers invariably patronise the professional when they require presentable photographs of themselves or their relatives.

Apprenticeship. A boy with the proper aspirations should be apprenticed to a good country business when he has reached the age of sixteen. In some cases a premium of £20 to £30 is asked; in others no premium is paid; and, again, small salaries are not unusual. A boy learns just as much at places where he receives a salary as where a premium is paid. The young beginner is taught printing, toning, developing, and mixing up solutions for a year or so, and is then introduced to the studio, where he helps in the operating, until he is competent to operate himself. Retouching is the last department taught. During these three years the young man should attend evening classes at the local science and art school. In London the excellent courses in photography at such institutions as the Polytechnic cannot be too highly recommended. The country lad should not, however, be discouraged by the lack of classes on photography in his town, but should occupy his evenings at the art classes, and go through a course of elementary chemistry, light, and heat in a science school.

Remuneration. The salaries paid in the business of a photographer are from 30s. to 45s. a week, the amount depending on the experience of the assistant, and on his ability as an operator. Many women are engaged in certain departments of the photographer's business, and they are quite successful as reception-room attendants, retouchers, printers, and mounters. The salaries paid to women range from 15s. to 30s a week, according to experience.

The Professional Photographers' Association has devised a "registration certificate" scheme for assistants. There has not yet been time to judge whether the scheme will be successful, but it may be added that it does not involve examination—merely a consideration of experience in the various departments of the business.

Starting in Business. To begin business is the aim of most assistants, but this step should not be taken until experience has been obtained in three different studios. Whether the photographer decides to buy an existing business or to start a fresh one is a question which circumstances must decide. As a rule, it costs the same in the long run, because, although the established business has a certain amount of goodwill attached to it, there is sometimes an undesirable reputation which neutralises the advantages. A photographer who starts a new business can soon make a reputation if he delivers his work promptly. The writer remembers a case in which the photographer built up a lasting reputation by delivering the finished photographs within three days of the sitting. It is a fact, however, that a beginner has often to make his name chiefly by work outside his studio. He will need to cater for work by taking local views, but should make a point of always being in his studio at certain times of the day, or he will never be able to build up a home business. As soon as the business is large enough to support an experienced assistant, most of the difficulties outlined above disappear.

Capital Required. It is hardly possible to state an exact sum as necessary for one starting the business of a photographer. Many have started on £20 or £50, but to start in a fairly comprehensive manner needs from £200 to £300. A studio, for instance, may cost £50 to £100, and the camera from £10 to £30. In the following estimate, a medium class of business has been taken as a basis of calculation:

Portable studio	£60
Furniture and carpets	20
Backgrounds and accessories	20
Camera, lens, and stand	25
Dark-room fittings	10
Apparatus (printing frames, retouching desk, washer, trimmer, rolling press, etc.)	10
Mounts and stationery	10
Plates, paper, and chemicals	10
Miscellaneous (including advertising)	15
Working capital	20
	£200

Premises. The above estimate provides for a portable studio, but it may be that waiting-rooms and dark-room will also have to be provided. Usually these last-named are the ground-floor

rooms of a house, and lead to the garden, where the studio is situated. Rents are higher in town, but a business is built up sooner than in the suburbs. Many town business premises are handicapped by having no shop window, the show-cases in a doorway being a poor substitute. If possible, have a shop window at disposal. The outside should be painted in a quiet colour—cream or plum colour are favourites—while for the inside of the window brown is to be recommended, as it shows up carbon and platinotype portraits best. The floor of the shop or reception room should be linoleum (self-colour), and the walls look nice if papered olive green, with white paint. The rule should be to avoid a pronounced colour. The furniture must be in good taste if a good-class business is to be cultivated; an oak gate-leg table and antique chairs help to give an air of culture, which educated people appreciate. Conventional furniture is not to be despised, and as customers have to wait some time, care should be taken to have comfortable chairs. Adjoining the studio a dressing-room should be provided.

The Studio. The studio is the most important consideration. It must be disposed so that the light is received from the north, or preferably from a north-easterly direction. The length of the studio should be not less than 24 ft. and the width 12 ft., although it is better, if space permit, to make it 35 ft. long by 18 ft. wide. The pitch of the roof is usually 35 to 45 degrees, the height to ridge being about 14 ft.

As regards the studio camera equipment, an average specification would be a 12 × 10 set, to cost, complete, £25. The camera is fitted with a dark slide to take one 12 × 10, one 10 × 8, one 8½ × 6½, two boudoirs, two promenades, two cabinets, and two carte-de-visite pictures. A good portrait lens and massive stand is also included. Many photographers start studio work with an ordinary outdoor outfit, with rapid rectilinear lens, and purchase proper studio apparatus as means permit. The other contents of the studio will be three backgrounds—a reversible neutral-coloured background, and one outdoor and one indoor scene—a head-rest, rugs, palms and grasses, and a few pictures for the walls.

The heating of the studio is best managed by means of a "syphon" gas-stove or by hot-water radiators, and it is essential that the studio be comfortably warm in winter, or successful results cannot be expected. The method of fitting up a dark-room is explained in the article on Photographic Dealers, which follows.

Mounts. The tints of mounts are numerous, but two kinds of mounts are well defined—Bristol and enamelled board. It costs about 5s. per thousand to have the photographer's name stamped on back and front of mounts, the price depending upon whether gold or colour is used. The table in next column gives approximate prices of the various mounts in use by photographers.

These should be supplemented by a selection of circles and ovals, slip-in mounts, and mounts with greetings embossed upon them.

VARIETIES OF PHOTOGRAPH MOUNTS.

Name.	Size.	Approximate Price.
Midget	2¼ by 1 5/16	3s. 6d. 1,000
Victoria Midget	2¾ „ 1½	4s. 6d. 1,000
Cabinet Midget ..	2 11/16 „ 1¾	4s. 6d. 1,000
Promenade Midget	3⅛ „ 1⅝	4s. 6d. 1,000
Boudoir Midget	3½ „ 2	5s. 6d. 1,000
Panel Midget ..	4⅛ „ 1¾	6s. 6d. 1,000
Carte-de-Visite ..	4¼ „ 2½	6s. 6d. to 15s. 1,000
Cabinet	6½ „ 4¼	16s. to 30s. 1,000
Promenade	8¼ „ 4	5s. 9d. to 7s. 6d. 100
Boudoir..	8½ „ 5¼	7s. to 9s. 100
Imperial	10 „ 6⅞	13s. to 16s. 100
Panel	13 „ 7½	4s. to 4s. 9d. 100
Large Panel	17 „ 10¼	6s. to 7s. 6d. 100
Grand Panel ..	23 „ 13¾	10s. to 13s. 100
VIEW AND GROUP MOUNTS		
¼ Plate	4¼ by 3¼	9s. 6d. to 20s. 1,000
.. .. ..	5 „ 4	15s. to 30s. 1,000
½ Plate	6½ „ 4¾	22s. to 50s. 1,000
Stereoscopic ..	7 „ 3 5/16	2s. to 10s. 100
„ .	7½ „ 5	
„ ..	8½ „ 6½	
—	10 „ 8	6s. 3d. to 12s. 100
—	12 „ 10	9s. to 25s. 100

Tissue paper covers for photographs, protector bags, and postal wrappers will be needed as well as memorandum forms and bill-heads.

A registration system for negatives must be inaugurated, a ruled book being provided in which the name and address of each sitter is entered with date and other particulars. The stock of negatives ought to be stored in a dry place and be put in order so that there will be no difficulty in finding a particular negative.

Selling Prices. Vary according to the class of trade. The following are average prices: *midgets*, 4s. 6d. to 6s. dozen silver prints, 7s. 6d. platino; *carte-de-visite*, 7s. to 8s. 6d. dozen silver prints, 10s. 6d. to 12s. platino; *cabinet*, 15s. to 24s. dozen; *boudoir*, 18s. to 20s. dozen to 35s. dozen; *panels*, 10s. 6d. to 15s. each; *wedding groups*, whole plate, one to two guineas, including three to six copies.

Copyright. In the case of ordinary photographs the copyright belongs to the person who pays for the sitting unless it is expressly reserved by the photographer. A book of forms should be provided for the latter purpose if the extent of the business allows it. The wording of the form is usually something like this:

"In consideration of your allowing me a reduction from your usual terms for taking photographs of me or on my behalf this day, I hereby agree that the copyright in such photographs shall be reserved to you, and that I will not deal in any way with the photographs to prejudice your interest in the copyright."

The reduction should be stated, and the agreement stamped with a sixpenny stamp, dated, filled in with the names of the parties, and witnessed.

Copyright in artistic property can be registered at Stationers' Hall, Ludgate Hill, London, E.C., the fee being 1s. Registration is necessary before a legal action can be taken against anyone infringing a copyright photograph. The Photographic Copyright Union, 23, Soho Square, London, W., and the Professional Photographers' Association, 51, Baker Street, London, W., are

useful societies for professionals; the subscription in each case is small. The Copyright Union recommends the adoption of a minimum reproduction fee of 10s. 6d. to a guinea according to the size. This is for newspaper work. For advertisement purposes the charges are higher; for postcards 10s. 6d. per 1,000 is a usual charge.

Class of Work. Photographer's work is very varied. It includes copying old photographs, enlarging pictures by bromide, carbon, or platinum processes, architectural work, photographic enamels, flashlight groups of dinners, lantern slides, transparencies, and photographs for the Press. In the old days, unmounted and mounted views had a large sale, but this has all disappeared before the ubiquitous picture postcard. Picture postcards are either direct photographs or collotypes. Collotype postcards cost 16s. 6d. per 1,000 if six subjects are taken, while for a set of 50 subjects the charge is 9s. 6d. per 1,000 if 10,000 are taken. Bromide postcards cost from 7s. to 12s. per 100, according to quantity and number of subjects. In the case of photographs for the Press, half-plate prints full of detail are preferred. A country photographer should arrange with an agent in London who sells photographs on commission to the various newspapers. The work needs to be done quickly. For dinner and ball-room groups a good flashlight apparatus is needed. Some photographers make a speciality of machinery photographs, and now that photographs are so much used for illustrating catalogues, this branch should by no means be neglected. For this class of work an air-brush, costing about seven guineas, is almost a necessity, as large spaces have often to be stopped out or retouched before the picture is fit for reproduction. Enlargements, miniatures, and fancy printing on opal, etc., are at first best left to trade printers, but the first-mentioned branch can easily be undertaken by the photographer, and it pays well if a special line be made of framed enlargements.

A side line neglected by professional photographers is the supply of plates, papers, and apparatus to amateurs. The article on Photographic Dealers should be consulted for details of this trade.

Frames and Framing. A valuable adjunct to the photographer's business is the sale of photograph frames. It is no use going in for this department unless the photographer has a really fine selection of frames and in all sizes—round, square, landscape and midgets. There are several styles which allow the frames to be used either upright or lengthways—for views or portraits. Midgets with round or oblong openings cost 3s. 6d. per dozen and sell at 6d. each. Carte-de-visites with round or oblong openings cost 5s. per dozen, and sell at 9d. each. Cabinets with round or oblong openings average 7s. 6d. per dozen, and sell at 1s. each. The panel cabinet size-frame either round or oblong costs 15s. per dozen, and sells at 2s., while the boudoir frame costs 17s. per dozen and sells at 2s. 6d. Picture framing [see Picture Framers] should also be a department of a photographer's business.

Advertising. Advertising is much neglected by photographers. If more price lists were distributed more people would be led to have their pictures taken. Make a special offer of a certain style of photograph or enlargement, but in so doing do not make a mistake of cutting prices; rather, make the quality and style better than charge a cheap-jack price. When sending home proofs enclose a price list of various styles in which the photographs can be printed, even though the customer has paid for the sitting. In many cases a few additional prints are ordered because some variation in style is fancied. The proofs sent should be from retouched negatives, and are best on printing-out paper. They should be stamped "to be returned," and, in case of neglect, should be charged for in the number ordered.

Profits. The photographer should obtain good profits, as his business is not on a par with one where goods are simply handed over the counter. Each customer has to be studied so as to get the best results in a photograph, and considerable artistic ability is required to retouch a negative and finish a photograph. These must be paid for as they involve an expenditure of time. The writer, endeavouring to work out the cost of carte-de-visites and cabinets on printing-out paper arrived at the figures 3s. and 5s; on platinum, the cost would be 4s. and 6s. 6d. As a matter of fact, it is not possible to arrive at the exact cost as it varies according to the extent of the business, but it may be taken that the gross profit is 50 per cent. on the turnover. A source of much loss with many photographers is the waste of material that goes on. Spoilt plates and paper, and wasted solutions, especially if the last-named contain the precious metals, account for a respectable leakage in profits. The leakage can be stopped by proper supervision and systematic working.

PHOTOGRAPHIC DEALERS

Photography is essentially a summer pursuit, and a business which has only a few months of activity is not a desirable one. Steps have been taken to educate the public to winter photography and magic-lantern work; but it is only the enthusiast who can dabble in ice-cold water and pretend that he likes it. Lantern work tends also to make the hobby expensive.

Qualifications. The photographic dealer should have a taste for scientific pursuits and, above all, should practise photography himself.

There is no apprenticeship in the business; the embryo dealer starts as a junior assistant, and works his way up. Wages are not on a liberal scale; 30s. to 45s. a week are fair averages for junior and senior assistants of experience, and it is not astonishing that any young man of enterprise and small capital soon looks about for a neighbourhood where he can set up in business for himself.

The best neighbourhood is obviously the busy residential suburbs of great towns or seaside resorts. Near public schools a photographic dealer can generally make a living as successive

generations of schoolboys take up the fascinating and educative art. It is true that it is often taken up for only a few months, but even this means a considerable expenditure in outfits. The boy's parents probably start the youth with a camera, as a birthday or season gift, unmindful of the fact that the camera is the least expensive part—comparatively speaking—of an energetic photographer's outfit.

The Dark-room. In connection with a photographic dealer's business, provision should be made for a dark-room for the use of amateurs. The room should be lighted by sliding shutters on the window and the source of light for the ruby lamp should be gas or electric light. Means must be adopted for obtaining white light at will, as some printing processes require a white light for a few seconds at a time. A by-pass is a useful addition to the gas burner, but with electric light a separate lamp for white light is readily fitted alongside the ruby lamp. The walls should be painted a dull lead colour, the same treatment being applied to the ceiling. Water should be laid on, and beneath the tap should be a porcelain or lead-lined sink. The tap to the water-pipe should be fitted with a reducing nozzle, and a rose cap is an advantage. The developing space should be on one side of the sink, and arranged so that splashes of developer and water drain away to the sink. Shelves underneath the sink and the developing bench should be fitted up for the dishes, while on the walls shelves are placed for the developing solutions and measures. Another table should be provided for the dark slides while filling them or while the plates they have contained are being developed. This table should be arranged at the opposite side of the room from the sink, so that it is not likely to get splashed. It is an advantage to have it away from the light, as plates should not be exposed even to red light unnecessarily. The room should be well ventilated. Any carpenter will understand when it is explained to him that he must make the ventilators light traps. The inside of the door also must be trapped round the edges, but this may be rendered unnecessary by the provision of a curtain on the outside. The door should lock on the inside so as to prevent the possibility of disturbance at critical periods of plate changing or developing. A refinement in dark-room doors is to have two doors separated by a lobby so that a person can enter the room without admitting light. In large photographic businesses several dark-rooms are provided. To casual customers a small charge—minimum, 6d.—is made for the use of the dark-room for plate changing, but if the customer be also a purchaser of goods at the shop it is unwise to press the charge. When the room is used for developing plates a charge of 1s. is made, this amount covering the use of the room for an hour.

Capital Required. The amount of capital required for starting the business of a photographic dealer depends upon whether it is to be subsidiary to another business, or to be mainly photographic requisites. When started in connection with a drug business, a ten-pound note would suffice to stock the most frequently required apparatus and plates, the chemicals being already articles of stock. Great care must be taken not to lay in a stock of plates and papers that will last beyond the season, as these goods do not keep well. It is better to replace the stock of perishable goods entirely each season, selling off the remains of last season's goods at sale prices to clear. When a new business is being started, the amount of capital will depend, in a measure, on the neighbourhood, but for the purpose of this article £100 is taken as a medium figure. It will be noted that no special brands of goods are mentioned, this being a matter which depends upon the wholesale house with whom the order is placed. It is also understood that the beginner desires scope for his energies in selecting the goods his experience suggests, and most suited for the requirements of the neighbourhood. There are new papers and plates being introduced every year, and fashion in cameras changes from season to season. This is especially the case with hand cameras, where last season's goods are looked upon as old-fashioned. This is a reason for caution in buying.

Estimate for a £100 Stock. The following is an approximate estimate of the manner £100 would be laid out in stock for a photographic dealer. The list was originally printed in the "Photographic Dealer's Annual."

	£	s.	d.
Two ¼-plate stand camera sets	2	2	0
One ½-plate stand camera set	3	10	0
One ½-plate high-class camera set, with 3 dark slides	6	0	0
Three daylight spool cameras, 1, 2, and 5 guineas	8	8	0
One flat film hand camera	3	0	0
Two magazine ¼-plate hand cameras	2	2	0
Two each camera cases, ¼-plate and ½-plate	0	9	0
One each camera case, solid leather, ¼-plate and ½-plate	1	6	6
Three camera levels	0	3	0
Three carriers, ½-plate to ¼-plate	0	2	6
One exposure meter	0	7	0
Three focussing cloths	0	4	6
Three each focussing screens, ¼-plate and ½-plate	0	1	9
Two focussing glasses	0	3	0
Two each R R lenses, ¼-plate and ½-plate	3	10	0
One anastigmat lens, ½-plate	8	0	0
One W A lens, ¼-plate	1	15	0
Two each roller blind shutters, T. and I., ¼-plate and ½-plate	3	18	0
Two each S S. shutters, ¼-plate and ½-plate	1	14	0
Two cheap drop shutters	0	3	0
Two tripod stands and tops, 3-fold	0	16	0
Two tripod stands, 2-fold	0	8	0
Two tripod stands, aluminium telescopic	1	1	0
One brilliant view finder	0	3	6
Two hand camera view finders	0	2	6
12 albums, assorted, for C.D.V., ¼-plate; cab., and ½-plate	0	15	0
Three camelhair brushes, 2 in.	0	2	0
Six 1s. handbooks on photography	0	6	0
Three each, cutting shapes, C.D.V., ¼-plate, cab., and ½-plate	0	6	3
Three boxes dark-room pins	0	1	6
Six bottles 6d. mountant	0	3	0
12 each deep porcelain developing dishes, ¼-plate and ½-plate	0	17	0
Six ditto, 10 in. by 8 in.	0	8	6
Three ditto, 12 in. by 10 in.	0	6	9
12 each composite celluloid dishes, ¼-plate and ½-plate	0	13	0
Three metal racks and tanks	0	4	6
Three each folding racks, ¼-plate and ½-plate	0	5	3
90 doz. ¼-plates, assorted brands	4	10	0
54 doz. ½-plate ditto	6	1	6
12 doz. 5 in. by 4 in. ditto	0	10	0
9 doz whole-plate ditto	1	18	3
12 doz lantern plates	0	12	0
Three yards ruby and orange fabric	0	3	0
Six 1s. ruby lamps	0	6	0

	£	s.	d.
Three 4s 6d. ruby lamps..	0	13	6
Six ruby lamps, assorted, for candle, gas, and oil	1	0	0
Three hock bottle lamps..	0	3	0
Assortment G.B.E. mounts for C.D.V., ¼-plate, cabinet, and ½-plate	1	10	0
Assortment slip-in mounts for ¼-plate and ½-plate	1	0	0
Assortment paste-down mounts for ¼-plate, ½-plate, whole plate, 10 in. by 8 in., 12 in. by 10 in. prints	1	10	0
Assortment fancy mounts..	0	15	0
36 packets ¼-plate gelatino-chloride paper, assorted brands	1	16	0
45 packets cabinet ditto	2	5	0
18 packets ½-plate ditto	0	18	0
12 packets whole-plate ditto	0	11	6
12 packets ¼-plate bromide paper	0	6	0
12 packets ½-plate ditto	0	13	0
Six packets whole-plate ditto	0	11	6
Three packets each, 10 in. by 8 in., and 12 in. by 10 in., bromide paper	1	0	0
One packet 15 in. by 12 in. ditto	0	6	6
Six ¼-plate wood negative boxes for 50 ..			
Four ½-plate ditto..			
Two japanned negative boxes, ¼-plate and ½-plate, for 12			
Two plate and print washers	0	9	0
12 each ¼-plate and ½-plate printing frames ..	0	16	0
Six each, 5 in. by 4 in., ditto	0	4	0
Three whole-plate ditto	0	5	3
Six print trimmers	0	3	0
One blade print trimmer	0	7	6
Three zigzag print trimmers	0	3	0
One retouching desk	0	8	6
Three retouching sets	0	3	0
Three sets hand scales, glass pans	0	6	0
Three sets pillar scales, ditto	0	16	6
Six roller squeegees, 4 in.	0	6	0
Three ditto, 6 in.			
Three each ¼-plate and ½-plate glass vignettes			
Assortment of plain and stoppered bottles ..			
Three dropping bottles		1	0
Three packets each, ¼-plate and ½-plate, backing paper		3	
Six ferrotype plates	0	2	

	£	s.	d.
Three packets masks and discs	0	6	
Six assorted lens caps	0	3	
Two each ¼-plate and ½-plate cloud negatives	0	2	
Two rose sprays	0	3	
Three each 2 dr, 2 oz., and 20 oz. measures ..	0	10	
One developing sink	5	5	
Small sundries	2	10	
	£100	0	0

The discount on this estimate would amount to between £25 and £30, which should be spent in the purchase of chemicals from the list which follows.

Photographic Chemicals. The list below shows the approximate cost and retail price of the chief chemicals used in photography, and also their uses. The prices do not, as a rule, include the bottles in which the chemicals are sold. Wholesale photographic warehouses supply most of the chemicals bottled in small quantities (1 ounce, 2 ounces, and 4 ounces), which is a convenience to dealers, but it is cheaper to purchase in bulk and to re-bottle into smaller containers if required. There are chemicals used in photography other than those given in the list, but all chemicals have been included which have a regular sale among amateurs and photographers. The chemicals should be kept in large bottles distinctly labelled, so that no mistakes can be made. The names printed in italics in the following list are alternate designations.

Put-up Goods. The photographic dealer will require to keep ready-made developers and

NAMES, COST AND USES OF THE CHIEF PHOTOGRAPHIC CHEMICALS

Name of chemical.	Wholesale price.	Reta price.	Uses.
Acetone	1s. 6d. lb.	3d. oz.	Instead of alkali in developer.
Adurol	1s. 8d. oz.	2s. 6d. oz.	Developer.
Aluminium powder	7s. 3d. lb.	1s. oz.	For flashlight.
Alum, powder	1s. for 7 lb.	4d lb.	Hardener for plates and paper.
Amidol	1s. 8d. oz.	2s 6d. oz.	Developer.
Ammonia, 880°	6d. lb.	2d. oz.	As alkali in developer.
Ammonium bromide	3s. lb.	6d. oz.	As restrainer in developer.
Ammonium sulphocyanide	2s. lb.	3d. oz	Constituent of toning bath.
Benzol	1s. 6d. pint	2d. oz.	Solvent for wax.
Borax	5d. lb.	1d. oz.	In toning bath.
Calcium chloride	10d lb.	3d. oz.	Siccative for platinum paper.
Cotton wool	1s. 4d. lb.	2d oz.	For filtering.
Eikonogen	12s. lb.	1s. 2d. oz.	Developer.
Formaldehyde	1s. 6d. lb.	3d. oz.	Hardening gelatine films.
French chalk	6d. lb.	1d. oz.	Cleaning glass plates.
Gelatine	3s. lb.	3d. oz.	As mountant.
Glycin	1s. 8d. oz.	2s. 6d. oz.	Developer.
Gold chloride..	1s. 8d. for 15 gr. tube	2s. tube.	Toning sensitised paper.
Hydrochloric acid (*Spirit of salt*) ..	6d. lb.	2d. oz.	Clearing platinotypes.
Hydroquinone (*Quinol*)	4s. 6d. lb.	8d. oz.	Developer.
Iron sulphate (*Green vitriol*) ..	1s. 6d. for 7 lb.	1d. oz.	Platinotype developer.
Litmus paper	1s. 3d. doz. books	2d. a book	Testing for acids and alkalies.
Magnesium ribbon	21s. lb.	1s. ½-oz. coil	Flashlight photography.
* Mercuric chloride (*Corrosive sublimate*)	3s. 6d. lb.	1d. oz.	Intensifying solution.
† Methylated spirit (*Alcohol*).. ..	2s. 8d. gal.	6d pint	Drying plates.
Metol	2s. oz.	3s. oz.	Developer.
Ortol	2s. oz.	3s. oz.	Developer.
Potassium bichromate	8d. lb.	1d. oz.	In carbon process.
Potassium bromide	2s. 4d. lb.	3d. oz.	Restrainer in developer.
Potassium ferricyanide (*Red prussiate of potash*)	1s. 10d. lb.	2d. oz.	Reducer.
Potassium hydrate (*Caustic potash*)	1s. 3d. lb.	2d. oz.	As alkali in developer.
Potassium metasulphite	1s. 6d. lb.	3d. oz.	Preserver for developer.
Potassium oxalate	7d. lb.	1d. oz.	Platinotype developer.
Pyrogallic acid (*Pyro*)	9d. oz. (bottles free)	1s. oz.	As developer.
Pyrocatechin (*Catechol*)	30s. lb.	2s. 6d. oz.	As developer.
Rodinal	1s. 3d. oz.	1s. 9d. oz.	Developer.
Sodium carbonate	3d. lb.	8d. lb.	As alkali in developer.
Sodium hyposulphite (*Hypo*) ..	9s. 6d. cwt.	2d. and 3d. lb.	Fixing plates and paper.
Sodium sulphite	5d. lb.	10d. lb.	Preservative for developer.
Sulphuric acid (*Oil of vitriol*) ..	6d. lb.	1d. oz. (by weight)	Preserving platinum developer.
Water, distilled	3d. gal.	6d. gal.	Making up developers.
White wax (*White beeswax*) ..	2s. 6d. lb.	3d. oz.	In encaustic paste.

* Can be sold only by chemists † Vendor must hold a licence

other solutions for his customers. These can be bought from a wholesale dealer, but if made by the retailer yield better profits. In making up developers distilled water should be used, as this makes clearer solutions. Good corks must be used, and, before putting them into the bottles, they should be dipped into melted paraffin wax to keep them from contact with the solutions. The bottles should be preferably of some distinctive shape, and if of amber colour the contents are not likely to be mistaken for medicine. Many photographic solutions are poisonous, but it is well to avoid giving the impression to customers. A stock of printed labels should be bought, upon which are given the directions and the name of the dealer. These cost about 5s. for 250, and are cheaper still in lots of 1,000.

It is fashionable to have developer in the form of tablets, and they are a great convenience when travelling. Most of the wholesale houses supply these, and will put the dealer's name on the packet when a fair quantity is bought. Branded kinds are made by Powell, called "Developoids," and Burroughs Wellcome & Co. call theirs "Tabloids." To use these tablets, they are crushed to powder in a little water, and the necessary quantity of water added.

Side Lines. It is becoming increasingly popular for amateurs to hand over their exposed plates, or films, to the photographic dealer for development and subsequent printing. Some amateurs do their own development, and hand the negatives over for printing. The profits are from 20 to 25 per cent on this class of work.

Repairs to cameras and apparatus should be undertaken, and arrangements made with a manufacturer for promptness in carrying out this work. Often a customer needs some adaptation. It is quite usual to have to fit filmholders to cameras originally made only for plates.

The hire of cameras is another branch of the dealer's business. A few good cameras accumulate through being shop-soiled, or possibly by exchange with a customer requiring a new instrument. The cameras should be in perfect order, and if the customer is unknown, a deposit up to the value of the apparatus should be insisted upon. The charge for apparatus is 5 per cent. of the value of the camera per week, with a minimum of 5s. The charge for the hire of a camera for a single day should depend on the class of apparatus; but a minimum should always be fixed, as the convenience of hiring is one for which a customer should expect to pay.

Lantern slides are let out on hire at many large photographic dealers, the charge for the hire of a set of slides being from 1s. to 2s. per night, the customer paying carriage.

Picture postcards are sold at present by many shopkeepers besides the photographers; but a photographic dealer specialising in high-class local views can be sure of the best class of trade.

Picture framing is suitable for this business, as photographic enlargements are generally incomplete without a frame [see Picture Framers].

Advertising. The photographic business lends itself in a peculiar manner to advertising. The makers of plates and papers supply specimen photographs taken on the articles of their manufacture, and very beautiful some of these prints are. It is, however, preferable that the displayed pictures should be of local interest, and if the photographic dealer be a practical man—and he should be—he will have no difficulty in making suitable prints for display in window and shop. The public will always stop and look at a picture, and they are much more interested if it is of a familiar scene, or of a curious out-of-the-way subject. A label, "Taken with our two-guinea camera," should be affixed to suitable specimens. An additional attraction is to be found in having an enlargement of unusual size in the shop. Such a specimen could be designed to show the degree of enlargement that photographs taken with a certain lens will bear, or it may be a specimen of the work that can be done from customers' own negatives. In dressing the window care must be taken to use only dummy packets of plates and paper, which can be obtained from the manufacturer. The window must be shaded from the sun, as the coloured leather of camera bellows bleaches if exposed to bright light for long.

A stereoscope on the counter, with a plentiful supply of stereographs, is good for amusing customers who are kept waiting, and a selection of the newest books and journals on photography should be placed within reach of the amateurs who frequent the shop. Several publications contain lists of photographic dealers and darkrooms, and, as names are inserted free of charge, there is no reason why the dealer should be backward in supplying the information. "Photogram" supplies an outside sign for dealers' use, which is useful in places where tourists are found. If there be a local photographic society, the secretary should be asked for a list of members, and the dealer should be unceasing in sending each member price lists and catalogues of novelties. Very nicely produced catalogues, which the dealer can adapt for his own use, are supplied by the wholesale houses, and bills and folders are sold by those who specialise in photographic printing.

Profits. The profits are good, but this should be qualified by the statement that much soiled stock is likely to accumulate if business is not brisk. The sale of such stock is, perforce, done at reduced rates, and, consequently, is profitless in some senses. The question of branded goods is one which troubles the photographic dealer. It is necessary in the case of plates and papers; but the extension of branded goods to the details of the business should be discouraged as much as possible, as branded goods may be cut in price, and injure the profits considerably. Price protection is in vogue in many photographic articles, and the profits are thus maintained. On apparatus and accessories 33⅓ per cent. profit is allowed, varying with the kind of goods, but some proprietary articles allow a profit of only 10 to 15 per cent.

Continued

DRAWINGS OF ENGINE DETAILS

Cylinders. Pistons. Crossheads. Connecting Rods. Crankshafts. Flywheels. Eccentrics. Valves. Pumps

continued from page 4329

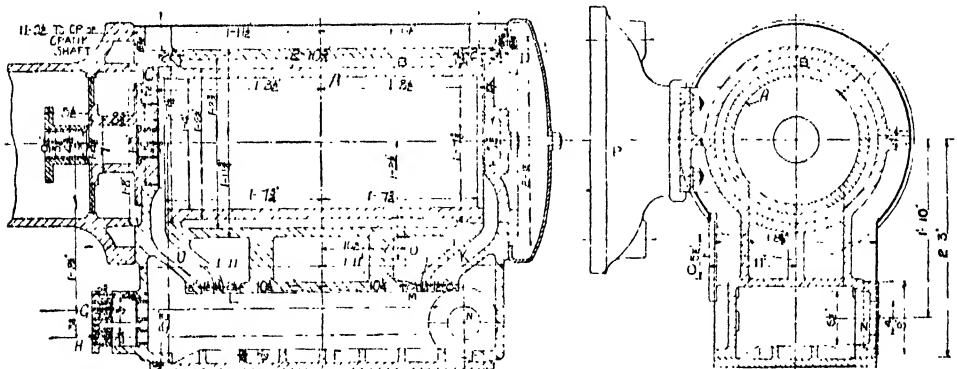
By JOSEPH W. HORNER

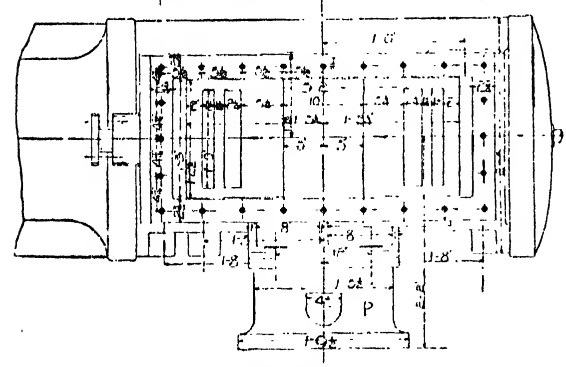
Cylinders. One of the principal *detail drawings* of an engine is that which represents the cylinder or cylinders. Fig. 152 shows a drawing of the high-pressure cylinder of a compound engine; the bore is 16 in. and the stroke of the piston is 36 in. The liner, A, is cast of harder metal than the cylinder body, and is forced into place by hydraulic pressure; the space, B, between the liner and the body is frequently used as a steam jacket—that is, live steam is admitted to the space in order to keep the temperature of the liner as uniform as possible. Small engines are not usually so made, but the cylinder body is simply bored out for the passage of the piston. The thickness of cylinder walls and liners is largely determined by practice; it is seldom less than $\frac{5}{8}$ in. for cylinders up to 10 in. bore; above 10 in. the following formula may be used:

$$T = \frac{D \times P}{3{,}000}$$

where T = thickness required, D = diameter of cylinder, and P = steam pressure in pounds per square inch. It would not do to simply calculate the thickness necessary to withstand the bursting effort of the steam pressure; there must be sufficient metal to ensure rigidity and to stand reboring after wear has taken place.

The cylinder ends and covers, C and D, are slightly thicker than the cylinder walls; the size and pitch of the studs or bolts which secure the cover affect its thickness to some extent. A good rule is to make the cover and the flange of the cylinder $1\frac{1}{4}$ times as thick as the cylinder itself, then the studs may be pitched $4\frac{1}{2}$ diameters apart for steam pressure up to 100 lb. per square inch, and $3\frac{1}{2}$ diameters apart up to 160 lb.





152. ENGINE CYLINDER

The diameter of the cover-studs is determined by calculating the load upon the cylinder cover, and apportioning sufficient area in the studs to meet the load; a safe stress is 3,000 lb. per square inch of stud area. Care must be used in taking the area at the bottom of the thread [see Table on page 3005]. Studs smaller than $\frac{5}{8}$ in. diameter are not to be recommended for covers, as they are liable to damage in tightening up with an ordinary spanner. The covers of small cylinders are made with a single sheet of metal; for medium cylinders this sheet is strengthened with ribs, while for large cylinders the covers are made hollow with internal ribs.

The front cover, C, is cast with the cylinder, and has a stuffing-box, or gland, fitted for the piston-rod to work through.

The Valve-chest. The valve-chest forms part of the cylinder casting, is of sufficient size to accommodate the valves, and is provided with a cover, F, and stuffing-boxes, G and H; the box G is for the main-valve spindle, and the

box H for the expansion-valve spindle. Steam-ports, U and K, are arranged from each end of the cylinder to the valve-chest; the ports L and M are for the exhaust steam. The area of the steam-ports should be such that the steam does not flow at a greater velocity than 6,000 ft. per minute, while the area of the exhaust port should allow a velocity of 4,800 ft. per minute; the calculation is then:

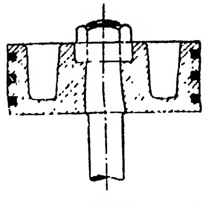
$$\text{Steam-port area} = \frac{\text{area of piston} \times \text{piston speed}}{6{,}000};$$

$$\text{exhaust port area} = \frac{\text{area of piston} \times \text{piston speed}}{4{,}800}.$$

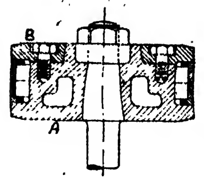
The length of the port—that is, the dimension measured at right angles to the length of the cylinder—is usually three-quarters of the cylinder diameter, and this being settled, the width of the port is easily calculated from the area. The wider the port the greater the travel of the valve, and it is sometimes necessary to make the port as long as the cylinder diameter in order to restrict the travel of the valve.

Steam is admitted to the valve-chest by the opening N, and exhaust steam leaves by the opening O, both of these apertures having facings to which pipe-flanges connect.

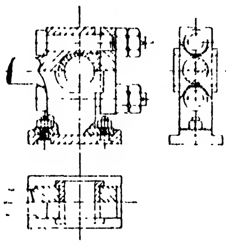
The front end of the cylinder is supported by the end of the main frame casting; a foot casting, P, takes the weight of the cylinder to foundation. Bosses are cast on for attaching a drain-cock at the end of the cylinder, a drain-cock for the jacket, and an indic[illegible] cock at e[illegible].



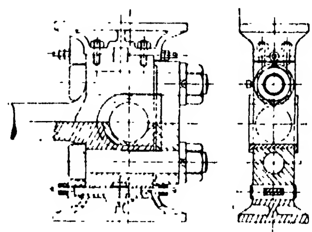
153. PISTON, WITH RAMSBOTTOM RINGS



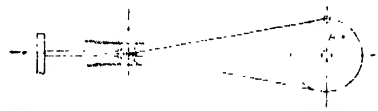
154. PISTON BUILT UP



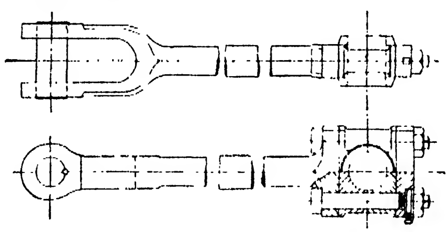
155. SINGLE SLIPPER CROSSHEAD



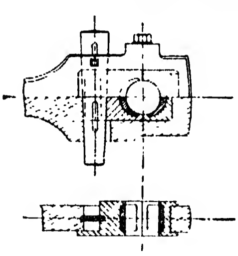
156. DOUBLE SLIPPER CROSSHEAD



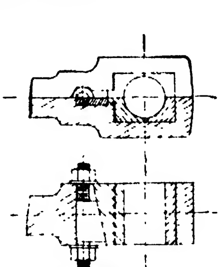
157. DIRECTION OF LOAD ON CROSSHEAD



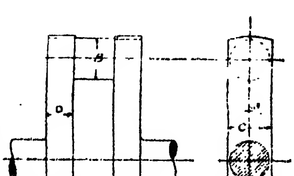
158. CONNECTING ROD



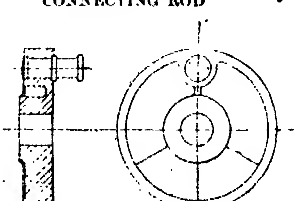
159. LARGE END OF CONNECTING ROD



160. SMALL END OF CONNECTING ROD



161. FORGED DOUBLE CRANK



162. CRANK DISC

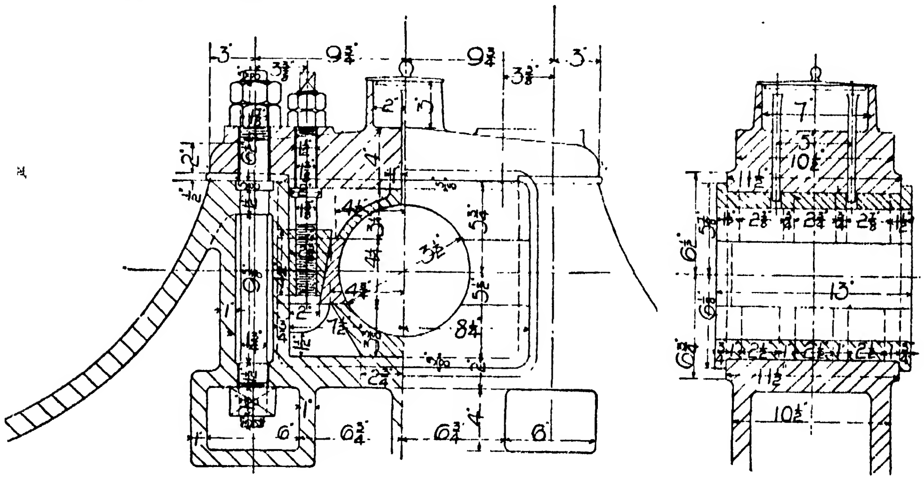
The whole cylinder is lagged and finished off neatly with sheet steel, a dished casting being fitted over the back cover.

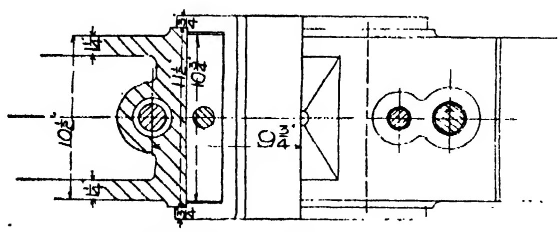
Clearance. The length of a cylinder is always slightly greater than the stroke plus the thickness of the piston—that is, there is a small space allowed at each end of the stroke. This space is termed *clearance*, and is necessary in order to prevent the piston coming into contact with the cylinder covers; it should be kept as small as possible, and may range from $\frac{5}{16}$ in. in small engines to $\frac{1}{2}$ in. in large ones. This space must be taken into account when calculating the amount of steam used in an engine; the same remark applies to the capacity of the steam-ports, as these have also to be filled and emptied at each stroke. The total clearance space in an ordinary engine is usually from 3 per cent. to 6 per cent. of the actual volume swept by the piston in its stroke.

Piston. A piston is not quite such a simple article as would appear at first sight, and, as a matter of fact, there are scores of different types in existence. The simplest form is shown in 153, and consists of a cast-iron body having three rings let into recesses; these rings are made slightly larger than the piston body, and are then cut through diagonally in one place; they are sprung into position on the piston and squeezed into the cylinder. The effort of the compressed rings is to expand constantly, and the resulting pressure on the walls of the cylinder makes

the piston steam-tight. These are known as Ramsbottom rings, and are made of steel, but cast iron wears better. When made of the latter metal they should not be less than $\frac{3}{8}$ in. wide. Another form is shown in 154, which presents a larger wearing surface than 153. There are two rings, both of which are cut through diagonally; a large spiral spring forces them outward to make them steam-tight against the cylinder. Such rings cannot be sprung into place, so the piston is made in two parts. The body, A, is a hollowed casting, as shown in 154, and a loose ring, B, termed a *junk ring*, is secured to the piston body and serves to keep the rings in place. The depth of a piston may be from a quarter to half of the diameter of the piston.

frame 135, page 4203. The end of the piston-rod is swelled up to receive a half brass, and to accommodate the cap-bolts of the other half brass; provision is also made for bolting on the cast-iron slipper which runs between the guide-bars. The cap and rod are of mild steel, and the slipper is easily renewed when worn. Fig. 156 illustrates a heavier type of crosshead made with double slippers, to bear on double guide-bars; reversing engines should have double guides. Looking at the diagram [157], and considering the engine to be running in the direction of the arrow A, it is evident that both the piston-rod and connecting rod are in a state of compression during the outward stroke; there is consequently a downward force acting on the crosshead, which





163. MAIN BEARING

is supported by the guide-bar. Now consider the return stroke, as shown in dotted lines. Here the piston-rod and connecting rod are in a state of tension, and consequently there is again a downward force on the crosshead. In fact, so long as an engine runs in one direction, the pressure on the guide-bar is always in the same sense. If the engine be reversed, then the direction of the force on the crosshead is reversed, and means must be provided to support it. The example given [156] is in general the same as 155, but the slippers are larger, and are secured to the forging by studs and square keys as shown.

Adjustment for wear is made by means of wedges let through the keys; these wedges are moved by the nuts on their screwed ends; the main bolts have lock nuts similar to those in 37 on page 3007. Crossheads are also made to work in circular bored guides, the slippers being turned to suit.

The diameter of the piston-rod may be calculated by the use of the formula:

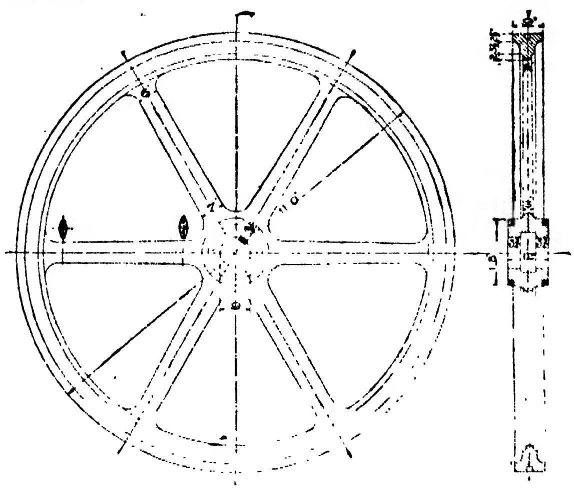
$$d = \cdot 013\sqrt{DLP},$$

where d = diameter of rod,
D = diameter of cylinder,
L = length of rod in inches,
P = steam pressure in pounds per sq. in.

The attachment of the piston to the rod is usually made with a taper end and nut, as shown in 153, but the taper is not absolutely necessary, for a parallel neck could be used and a shoulder or collar provided at the front end. A good taper is $1\frac{1}{4}$ in. of diameter to 12 in. of length.

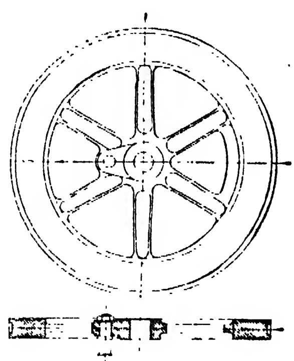
Crossheads. Crossheads are made in great variety; 155 shows a single slipper crosshead, such as might be applied to the engine frame 135, page 4203.

Connecting Rods. Fig. 158 shows a connecting rod of marine type suitable for working with the crosshead illustrated in 155. The end

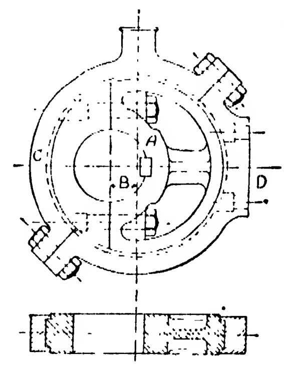


164. ENGINE FLYWHEEL

is forked to embrace the crosshead, and the pin is kept from turning by means of a small stop-pin, as shown; the rod is circular, and is forged with a head-piece to take the gunmetal wearing-blocks. These blocks are divided at the centre, and are held together with two bolts passing through them. An outer steel cap takes the bending movement due to the pull on the rod. The nuts on the bolts are similar to 37, page 3007, but the steel cap receives the locking screw in place of a separate collar; in small engine work it is usual to use ordinary double nuts. Connecting rods, like piston-rods, are subjected to alternate tensile and compressive loads. As they are weakest in compression, they are designed as struts or columns, but allowance must be made for the inertia of the rod itself, and this factor—especially in high-speed engines—makes the calculation quite a complicated one. The following empirical rule due to Seaton agrees closely with modern practice:



165. PUMP FLYWHEEL



166. ECCENTRIC

Diameter of connecting rod in middle $= \dfrac{\sqrt{LK}}{4}$

where L = length of connecting rod in inches

and K = ·03 × $\sqrt{\text{load on piston in pounds}}$.

The length of a connecting rod is usually two and a half to three times the stroke of the piston. Figs. 159 and 160 show two other types of connecting-rod ends, both of which have solid ends and adjustable brasses. The former is adjustable by cottar, and has a Babbitt lining; the flanges of the brasses are left off on the top and bottom on one side so that the brasses may be put in place sideways. The example 160 is used for the crosshead end of the rod, in which case it enters a socket in the crosshead; it is adjustable by means of a wedge-block and nuts, as shown. The crankshaft end of a connecting rod is termed the *large end*, and the crosshead end is termed the *small end*.

Crankshafts. The Board of Trade rules for marine crankshafts are as follows:

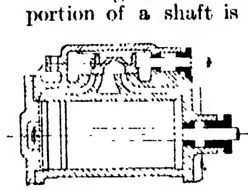
Let S = diameter of shaft in inches.
P = absolute boiler pressure.
C = length of crank in inches.
D = diameter of low-pressure cylinder.
d = diameter of high-pressure cylinder.
f = a factor depending upon angle of crank.

For compound condensing engines with cranks not overhung,

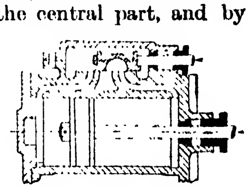
$$S = \sqrt[3]{\frac{C \times P \times D^2}{f\left(2 + \frac{D^2}{d^2}\right)}}$$

The values for f may be taken from the table on the next page.

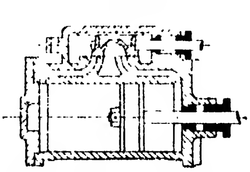
Ordinary crankshafts with overhung cranks may be calculated for combined bending and twisting in a similar manner to the example given in 49 on page 3135. Hollow shafts are made in order to save weight of material; the least effective portion of a shaft is the central part, and by



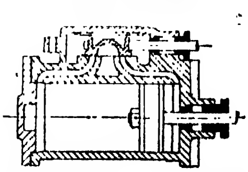
167. VALVE ADMITTING STEAM



168. VALVE FULL OPEN FOR STEAM



169. VALVE CLOSED FOR STEAM



170. VALVE CLOSED FOR EXHAUST

removing it the weight of the shaft is diminished in a greater proportion than the strength.

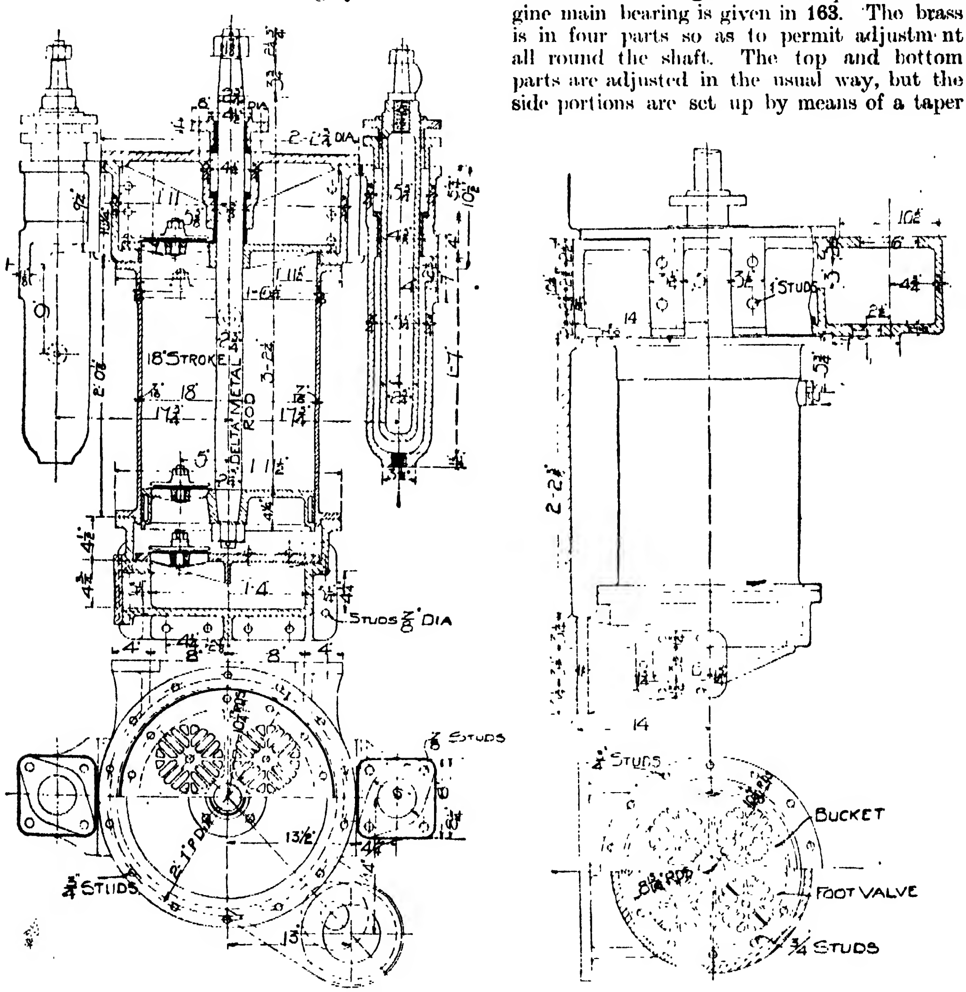
Angle between cranks	90°	110°	120°	140°	160°	180°
Value for f ..	1047	904	855	788	751	740

The modulus of a hollow circular section is found by subtracting the moment of inertia of the inner diameter from the moment of inertia of the outer diameter and dividing by the radius of the outer diameter. A table of moments of inertia is given on page 3134.

Cranks may be forged with the crankshaft, or they may be separate pieces keyed on the shaft. A forged crank is shown in **161**: it is generally machined all over, and the ends turned in the lathe about the centre, A. The diameter of the pin, B, is usually the same diameter as the shaft; the width, C, is one and a quarter times the shaft diameter, and the thickness, D, is three-quarter times the shaft diameter. The cranks and pin may be separate pieces; in which case the cranks are swelled out to fit over the shaft and over the pin; the thickness of metal allowed in the swelled parts should not be less than ·4 of the shaft diameter.

Cast-iron crank discs are made as **162**, the crank-pin is fitted in tightly, and the end riveted over; the metal is thickened up at the side opposite the pin for the purpose of balancing the connecting-rod head.

Main Bearings. An example of an engine main bearing is given in **163**. The brass is in four parts so as to permit adjustment all round the shaft. The top and bottom parts are adjusted in the usual way, but the side portions are set up by means of a taper block and screws, as shown; the drawing explains itself.



171. AIR AND BILGE PUMPS

Flywheels. The theory of flywheels is discussed on page 2018 in Mechanical Engineering. Fig. **164** shows an ordinary flywheel; the rim is solid and is arranged with pockets round the periphery; these pockets are used for starting the wheel from rest when the engine is on dead points. The appliance which effects the starting is termed a *barring gear*, and may range from a simple lever to a separate small engine. The arms of the

wheel are oval, and they taper from the boss to the rim. The boss has wrought-iron rings shrunk on to give it increased strength.

A smaller flywheel is shown in **165**; the arms are rectangular in section, and cranks are cast with the boss; such a wheel would be used on a small pumping engine. The inside of the rim opposite the crank-pin is thickened up to balance the pump-rod head.

Eccentrics. Eccentrics are used to give reciprocating motion to the valve-rods on an engine; a common example is shown in **166**. The inner part, or sheave, A, is keyed to the shaft; the centre of the sheave does not coincide with the centre of the shaft; the distance apart, B, of the centres represents half a stroke of the strap C, and the eccentric rod is bolted up to the end, D. Both strap and sheave are in halves for convenience of renewal, but the sheave is not always in halves; the straps must be made so on account of getting over the register, which keeps it sideways.

Valves. A simple D valve is shown in various positions of stroke in **167** to **170**; the stroke of the valve is due to the eccentric. In **167** the valve is just open to steam, the piston is at the beginning of its stroke, and the connecting rod and crank are in a horizontal line—that is, on dead centres. The exhaust port is nearly full open. In **168** the valve is full open to both exhaust and steam, the piston is travelling along the cylinder, and the crank is at 45 deg.

In **169** the valve is reversed by the eccentric, and has closed the steam-port, the piston is moving forward under the influence of the expanding steam, and the exhaust is partially closed; the crank is well over 90 deg. In **170** the exhaust is closed, and the valve is moving to open steam for the reversal of the piston stroke. There are many types of valves in use, but their duties are all identical—namely, to regulate the flow of steam and exhaust to and from the cylinder economically.

Pumps. An air-pump together with two bilge-pumps are shown in **171**. The air-pump is of brass, though not necessarily so, and the thickness of its walls is kept down to a minimum, as the metal is expensive. The piston is termed a *bucket*, and is fitted with non-return valves for lifting water; the top and bottom of the pump are fitted with separate plates carrying similar valves. The bilge-pumps are of heavier metal, as they have to pump against a head; they are used for pumping the bilge-water from steamships. The plunger displaces a volume of water equal to its bulk at each stroke. Both bilge-pumps and the air-pump are driven from a single crosshead, operated by the air-pump levers. The bilge-pump valves are simple in construction, and are fitted in the piping connected to the pumps.

In an engine fitted with a jet condenser, the air-pump has to remove the condensed steam, the water used for condensing the steam, and the air which enters with the water. In a surface condensing engine the air-pump removes the condensed steam and any air which may enter the engine; the condensing water in such cases is dealt with by separate pumps, termed *circulating* pumps.

Size of Air-pump. The size of the air-pump for a condensing engine may be determined by the following rule:

$$\text{Volume of air-pump} = \frac{\text{Indicated H.P.}}{\text{revs. per min.}} \times C$$

where C = 700 for single-acting and jet condenser,

C = 300 for single-acting and surface condenser,

C = 470 for double-acting horizontal pump and jet condenser.

Another rule is to make the capacity of the air-pump one-twelfth of the capacity of the low-pressure cylinder. There are so many contingencies to be allowed for in the working of an air-pump that pure theory cannot be relied upon in the design. The action of the pump is not perfect inasmuch as it does not remove at each stroke an amount of water, etc., equal to its capacity. Ordinary pumps are defective enough in this respect, but air-pumps, and particularly vertical ones, are very inefficient. The speed of the pump affects its efficiency to a great extent; the best results are obtained at a bucket-speed not exceeding 200 ft. per minute; many examples are, however, to be found running at as high a speed as 450 ft. per minute at a lower efficiency.

The limit of speed is that at which the water can follow the bucket and so provide a full barrel for the next stroke, and this in turn depends upon the vacuum maintained. The pressure of the atmosphere is 14·7 lb. per square inch, and a good vacuum is 2 lb. per square inch; it is not possible to maintain a perfect vacuum in practice. The theoretical velocity of water under a pressure of 2 lb. per square inch is 1,025 ft. per minute, but it would not do to speed the pump bucket accordingly. Allowance must be made for friction, for the inertia of the water, and for the presence of air and gases in the water; this can only be determined by practice, and the speed range of 200 ft. to 450 ft. per minute as given above is deduced therefrom.

Fouls. It will be noticed upon examination of the sectional elevation of **171** that one bucket valve is shown dotted at the upper end of the stroke, while the bucket itself is shown at the lower end of the stroke; there is an object in doing this, and one which must be ever present with the designer of moving machinery.

Wherever one part of a machine moves relatively to another part it must be drawn in its extreme, and sometimes intermediate, positions in order to avoid fouls. All the various movements must be carefully plotted on paper beforehand in such a way as to ensure the complete and smooth working of the whole machine. It sometimes happens during manufacture that through an oversight in the drawing office a machine cannot complete a cycle of movements without a foul of some nature.

DRAWING FOR ENGINEERS *concluded; followed by* DRAWING FOR SHEET-METAL WORKERS

THE EDITOR & HIS PAPER

The Editor of a Great Newspaper. Functions and Ideals of Editing. The Editor's Duties to His Readers. Office Journalism

Continued from page 4316

By ARTHUR MEE

TO be the editor of a great newspaper is an achievement of which any man may well be proud. To help to shape the opinion of a nation or to entertain it in its leisure hours is a function which, if it is honourably fulfilled, rightly brings a man esteem and fame. There is not a journalist with the essence of journalism in his soul who would not rather be an editor in deed than a prince in name.

The Ideal Editor. It is a compelling theme, the business of the man whose pen Napoleon feared more than 30,000 bayonets. Nothing could be much more interesting, if we had space, than to consider it in its relation to life and affairs. Nothing could be more interesting, and nothing could be more comprehensive. For the editor is a many-sided man, who touches the world at all the points we can conceive. His duties and responsibilities reach out through countless avenues. He owes to every man in his public relations the consideration which one gentleman owes to another; it is one of the first maxims of his life to do nothing as a journalist that he would not do as a gentleman. He has something of the duty of the preacher to lead people towards the right and warn them from the wrong. He must have some of the foresight and something of the delicate craft of statesmanship. He must have the ingenuity of the advocate with the impartiality of the judge, and he must weigh great problems in all their bearings as if he were a jury. He must be able to exercise the grave care of a doctor who hides the truth from his patient for his patient's good; he must know exactly what to say and when to say it. He must have the soul of the artist for interpreting and revealing the meaning of things; he must be moved by the spirit rather than by the letter. He must have the imagination of the poet with the veracity of the scientist. He must have the astuteness and caution of the diplomatist when a crisis is looming, the calmness of the philosopher and the dignity of a king when the crisis has come. He must be a patriot in the highest sense of patriotism, with a love for his own country the more profound because he loves the human race. He must have, all this is to say, far more than an average share of the qualities of the ideal man.

The Ideal Paper. Somewhere, far away from Fleet Street, is such an editor; somewhere, farther from Fleet Street still, is his ideal paper.

The ideal paper is the story of men and women. That, after all, is the beginning and the end of papers. It is the business of a paper to compel a great public to read it, and the ideal paper comes with such compelling force as it can find in the simple, human story of the world.

It finds its interest in no narrower field; it draws its drama from no narrower stage than the world in which all the men and women are actors. It tells us, week by week, the wonderful story of the world we live in—such a story as bewilders the writer of fiction, stranger in its truth than dreams, more startling in its reality than all imaginings, more beautiful in its unfolding than all the poet's thought. It tells the story of men and women, the story of a man and a maid. "It cometh unto us with a tale which holdeth children from play, and old men from the chimney corner."

The Editor's Raw Material. So entrancing, could it be brought before us, is the history of our own times. There died not long ago, unnoticed in our papers, an old woman in a country poor-house, lifting the veil in her last moment from the tragic mystery of a Royal Court. There was carried from a lowly house, not many years ago, the dead body of the president of a great republic which has never known the truth of his strange end. There passed away by fire a year or two ago a beautiful woman, a sister of two queens, who would have been a queen herself had not a king broken his word; there lives still a woman whom the same king loved, who might have left a village inn for a German throne, but who, instead, came in a boat upon a lake one day to see her young king drown. Almost in the shadow of our own King's castle lives a widow who sat upon the throne of France. Not an hour's journey from her there lay, the other day, broken in fortune and at the door of death, a widow whose winsomeness split parties in the House of Commons and dashed a nation's hope. The greatest of all human stories is written by the hand of Fate.

The Scope of the Paper. That, as far as it can be stated in a word, is the keynote of the ideal paper. It is human. It is true. It is interesting because it is life. It takes account, not of names, but of things. It is planned on no arbitrary lines, but is fashioned by affairs as they occur. It picks up the threads of romance wherever they may be found. It knows neither time nor place; it gathers its story from the ends of the earth and from all ages. It is universal in its scope. It appeals to the man who has read everything and to the man who has read nothing. It is conducted on the principle that nothing interesting is ever old, and that everything human is interesting.

It believes that men and women are interested in themselves and in the race. It realises that the most wonderful thing in the world is the

world itself; that the things we know least about are the things of which we wish to know most. It finds romance in the sky and the bottom of the sea. It does what in a paper lies to make men and women know themselves. It tells the story of all the great discoveries and inventions that are changing the face of the earth.

We live in an age of miracles. "I never handle the telephone without realising that I am handling a mystery," Sir William Crookes has told us, and he puts well the truth that, so far and so fast has the world moved, that the greatest mysteries in the universe are almost commonplace. We lay our sixpence on the post-office counter and think nothing of the electric wires which will convey our message from Edinburgh to St. Ives before we are at the bottom of the street. We open our papers in the morning as carelessly as if it were not a miracle which has brought to our breakfast-table the history of the last twenty-four hours from every part of the earth. We strike a match without thinking that the light that comes is nothing less than a bit of sunlight imprisoned in the earth for thousands of years. We switch on the electric light without fear and trembling, playing like children with the appalling power of which science knows almost nothing. We pluck a rose without a thought of the unseen and silent forces which have wrought so beautiful a thing.

A Human Picture of the World. The romance of the world can never be written, can hardly be conceived. But such threads as can be caught the ideal paper takes, weaving them into the picture of our day. It has all the faults of a paper made in haste and read at leisure, all the evidences that a penny, after all, cannot buy everything. But it is an enthusiastic endeavour to make up the best magazine of helpful and interesting journalism that can be secured for its price. It makes its appeal to all—from the smallest child who would hear a story, to the man who would know what new thought has been spoken, what new height in science has been reached, what is happening in any part of the world that will leave its mark on history. Nor does it ignore the problems of life. Every issue of it discusses some social subject of interest to the individual and the home. It strives to bring the best thoughts to bear on the best topics of the day; to pick out the truth as well as the romance from the affairs of the world; to keep itself abreast of all that happens that an intelligent man or woman should know, to be, from beginning to end, interesting and helpful and true.

The ideal paper is a human picture of the world, beating with the lives and the hearts of men.

It is the paper of a dream, the dream of every editor who is awake. How near sometimes we get to it, how far from it sometimes we are, is a good or ill-fortune dependent on many things within and without the editor's control. It is not intended in this course, necessarily brief and suggestive, and in no sense exhaustive, to go into all the questions that come to the mind when we meditate upon editors and papers. Those who have read so far will have formed some conception of what we hold journalism to be; those who have reached this stage in actual journalism will need no advice here as to how to advance still further. All that we need attempt is a brief consideration of one or two practical matters concerning the editor and his staff.

Good Copy and Bad. The editor must not succumb to the temptation, so strong in these days, to think more of the machinery of his paper than of its readers. The story of how he obtained a piece of news may be interesting, and in some cases it may be quite legitimate to tell it; but the chief matter is the news itself, and not the getting of it. It is, of course, important sometimes to know the source from which news comes, but the talk about these things has come to be more of a desire to advertise the paper's machinery than to satisfy the public as to the authority of the news, and in so far as this is its object, all display is to be condemned. Waste of space is one of the unpardonable sins. One of the most remarkable popular delusions is that editors are gasping for something to put in their papers. The difficulty at the last moment is always, "What can we leave out?"

That question must be decided by the editor, who knows his readers. He will probably decide to leave out the thing that interests the least number, although this may not always be so. He will, at any rate, leave out the non-essentials first. His whole purpose in leaving out news will be to sacrifice as little of the general interest of his paper as possible. Only long experience of editing can help him here, but he should have no difficulty in deciding what copy is good, and what copy is bad. An editor confesses his own weakness when he publishes long accounts of trivial things, or allows anybody who has nothing better to do to occupy his space by writing silly letters. The standard of letter-writing in papers is much too low, and it is simply bad journalism which enables a man to become notorious by writing letters about gravestones when he has nothing to say about them that matters to anybody.

The Chief Figure in the Editor's World. The editor is safe from these temptations if he remembers that the most important person in all the world to him is the reader of his paper—not the advertiser, not the proprietor, not the man with a log to roll or an axe to grind, but the man who buys his paper to read it.

One of the worst enemies of journalism is the proprietor or commercial manager of a paper, usually calling himself the managing-editor, who, knowing nothing about a paper save that it prints advertisements, dictates to the editor how he shall edit. The last person in such a man's mind is the reader of the paper. One of the best of these managing-editors that we have known once refused to order the report of a speech by Mr. John Morley, owing to a dispute between his paper and a certain press agency. It was nothing to him that he was withholding from his readers something it was his duty to give them, something the great majority of them expected to see when they opened the paper; it was everything

to him that he should spite the face of the press agency—even by cutting off his own nose.

The Morality of Editing. Somebody will write a book some day, perhaps, on the morality of editing, and it will contain many examples of this kind. It will also publish a copy of an announcement in a provincial morning paper that "in attending meetings, etc., preference will be given to those fixtures advertised in our business columns." It will print such letters as that written by the manager of a well-known evening paper in reply to a publisher who had sent him books for years, and had had no reviews. The publisher wrote to ask if the paper wished him to continue sending the books, and the manager replied that his newspaper believed in the old-fashioned principle of *quid pro quo*, and as the publishers did not advertise in it they got no reviews." These are the things which distress the journalist who conceives it his duty to be a faithful recorder of news, and to keep his readers well informed about literature; but they are done, let us remember, not by journalists, but by men to whom a newspaper is a thing for advertising pills.

The good editor knows every man on his staff. He knows where to turn when, late at night, he wants a leading article quickly, a special introduction to some important event, or a sketch of somebody's career. He knows the man on whom he can rely for initiative, for descriptive power, for getting hold of people, for evolving theories, and following them up. And if the good editor knows his man, the good journalist knows his editor. He knows his editor's point of view, understands his purpose, and responds to it.

The Men an Editor Likes. The news editor of a newspaper with a reputation for enterprise throughout the world has written for the SELF-EDUCATOR his conception of the kind of men an editor likes to have about him. He says:

"The sub-editor needs a good education, and especially a sound knowledge of spelling; a catholic and quick judgment as regards the value of news, and a clear conception as to the most interesting form in which the news is to be printed in his paper. He should be well informed generally—an ordinary school or college education is adequate, coupled with a close study of newspapers, whereby he assimilates the events of the day He should have a keen recollection of occurrences in the past, immediate and more remote, an unfailing memory for names, a sound judgment as to 'possibilities' in the reports which reach him. Shorthand is useful, but not vital

"The older sub-editing is, for the most part, the abbreviation, the punctuation, and the checking of reports sent to the office, either telegraphed or written; the newer sub-editing—for instance, of the ultra-modern papers—requires extensive rewriting and constructive reproduction. All this can be acquired by practice. Patience, however, is necessary, method essential, and discretion vital. Only by the possession of these qualities by its sub-editorial staff can a paper attain a high standard.

"While a sub-editor should have a general knowledge of newspaper work and an all-round education, he should at least know one modern language, preferably French, and should specialise on one subject—for instance, medicine. Finally, he should never be above verifying a reference or checking a quotation. And in his spare time, if he has any, let him make himself familiar with events outside his office. The best sub-editor is always a 'man of the world.' He knows the public pulse and the public taste, and can better estimate thereby the specific value to be attached to specific news.

"No one unless possessed of strong physique should become a sub-editor. The work is sedentary, and the strain on the nervous system severe. There are always openings for good men. But it is essentially routine newspaper work, which only needs ordinary intelligence, rightly trained; and few persons of special genius ever devote themselves to it for long, for it offers no opportunities for ambition, and exercises a numbing influence on its votaries."

Office Journalism. We can now leave office journalism. We have considered all too briefly the work of a newspaper journalist, from the moment he makes up his mind to become a journalist to the time he becomes an editor; and we have now to consider that wider field in which journalism ceases to be a profession and is open to all the world. It is not necessary to discuss the thousand and one duties of an editor, which the journalist must learn for himself. We have said nothing of the salaries paid in a newspaper office, because it is impossible to give any figures which would not be misleading in some cases. The apprentice who enters the reporters' room may begin with a few shillings a week, and rise until at the end of his apprenticeship he receives, perhaps, 16s. or £1 per week. In an ordinary town he may then receive a salary of £2 or £3 a week as either reporter or sub-editor; or in a large town, such as Manchester or Birmingham, a salary of £5 or £6 a week. The custom is growing of paying reporters according to the work they do instead of a fixed salary, and this custom, often adopted in London, is preferred by some reporters. In this way a reporter may earn as much as £10 or £15 in a week if he is fortunate. In any case, if he is a good, reliable man he can always be sure of a living income in London. Necessary expenses are always allowed. A sub-editor's salary is, of course, fixed, and may be anything in London from £4 to £10 a week.

Whether as reporter, sub-editor, leader writer, musical or dramatic critic, special correspondent, or in any other capacity, the journalist will find opportunities for distinction inside the newspaper office. Office journalism has its drawbacks. It involves long hours, and leaves a man little freedom of movement. But it has abundant compensations, and he may look forward, if he is strong and willing and enthusiastic, with the certainty that he will have plenty of opportunity of putting into his work the best that is in him.

Continued

continued from page 4242

TOP-MAKING

The Machines and Processes in Factory Practice. Clicking, Machining, Skiving, Buttonholing and Finishing

By W. S. MURPHY

Cutting Tops. Machinery is not much used in the cutting-rooms of factories producing first-class boots. The matter has often been debated on this side of the Atlantic, because on the other side cutting machines are largely used. American methods, however, differ largely from ours. For our own trade the subject may be considered in this way. Leather is not like a web of cloth, the uniform quality of which can be depended on. A web of cloth is the same breadth and thickness throughout, and one web is exactly like another. On the other hand, no two hides of leather are similar in every respect, and qualities vary indefinitely, even in the same class of stuff. In cutting up leather, the selective eye cannot be dispensed with.

Cutting by Machinery. If a man is prepared to risk defects and incur a large percentage of waste, he may go in for cutting by machinery. Under special circumstances, perhaps, the loss in waste is balanced by the saving in wages, for machines in this department do effect enormous savings in labour. Working with cheap leather, for a coarse trade, the manufacturer may find cutting by machinery a paying business; but with leather costing about 3s. per lb. all over, and buyers scanning every fibre for damage, hand-cutting is the safest and the best.

The Clicker. The *clicker*, as we name the top-cutter, has a bench space all to himself, and a special class of boot to cut. In a factory producing for an all-round trade, clickers are ranged in classes or sections, one section cutting for the "nursery" department, another for the girls', another for the women's, for the boys', for the men's, and for the fancy departments. Some large factories have over a hundred clickers working, divided into sections varying in number from seven to 20, according to the class of trade or system of management. When it is remembered that the tops of a pair of half-goloshed Balmoral boots contain 36 pieces, including linings, the possibilities of division and subdivision are obvious.

Clicking a Skilled Craft. Clicking in the factory differs little from top-cutting for the hand-made boot. The clicker is a handicraftsman who is required to show special skill within very narrow limits. He should be able to tell at a glance the different classes, kinds, and patterns of leather. His duty is to detect defects in fibre or pattern, and plan to cut out of the hide in the most economical manner possible. The clicker who wastes leather is certain to be among the unemployed more frequently than may be pleasant. We have already shown a picture of the kinds and patterns of leathers most commonly used for the boot trade in this country, illustrating the distinguishing qualities of each [see Plate facing page 3217].

The Clicker at Work. Now, let us get to work. Knives [29, page 3875] are the clickers' tools, and he must keep them in good condition. The slightest roughness on the blade may mean a ragged edge on the leather just at that point where it has been cut neat. A properly organised factory gives out work cards, with the details of the particular job specified. Suppose that our work card contains the order for a dozen of half-goloshed Balmoral boots of first-class quality. The quarters are to be the best calf-kid, the golosh and vamps French calf, and the facings and toecaps patent or enamel leather. Having selected the pieces, we next go to the pattern file, and take off the set of patterns proper to the size of boot. Before beginning to cut, plan out the stuff; a little forethought may save the leather of a pair of tops. When assured that the most has been made of the material, take the patterns and carefully cut cleanly and swiftly. Mind the corners. If the points have been well cut, every piece will come away as cleanly as if it had been struck by a die. Ragged ends give you more work, or somebody else has to lose time in rectifying the defect.

Linings. The linings and other accessories are similarly gathered. For light boots of the best quality fine leathers are sometimes used; but good drill serves the purpose quite well.

Small Machines. We have said that machinery is not wholly debarred from the clicking-room. Tongues, toecaps, and the other small additions are generally cut by machines worked by boys. Neat little things those machines are. Here is one, looking very like a sewing machine, and it is used for cutting out and perforating toecaps, cutting and scolloping button-flaps, and such purposes [47]. Another little machine, equally interesting and efficient, is the tongue and backstrap cutter. The knives can be adjusted to any angle, and scraps of leather passed through come out well-shaped tongues. The backstraps, of course, are of good leather; but the pieces may be useless otherwise, and the machine makes them into fine straps in the twinkling of an eye. As there is nothing to learn in these machines, elaborate study of them is needless. Any lad brought in from the street can be taught to work them in a very short time.

We gather together our stuff, and bundle it up, each part separately, and hand along to the inspecting department. Thence the tops pass into the machine-room, and begin the journey towards the destined end.

The conditions under which clickers work are usually very good and healthy, light and

ventilation being provided by employers from purely economic motives. The work is pleasant, but not very well paid

Patterns and Measurements. Wherever material is elaborately cut out, there must be patterns. The pattern everywhere saves time, trouble, and material. Upon the pattern-maker rests the efficiency of the whole boot factory. He it is who gives the clicker the shapes to which he must cut all the parts of the boot-top.

Thousands of Shapes. A shape is a piece of stiff paper cut to a given form and size [see 30, page 4015]. For every part of every size and class of boot there is a pattern. In this way the pattern-maker seems to have plenty of work before him; but that is not all. New shapes are being devised every week, and a factory producing for a high-class shop trade has a thousand or two special measures coming in every week. No decent-sized factory can get along with less than ten thousand different patterns, and these duplicated as required by the number of clickers employed on each class of work.

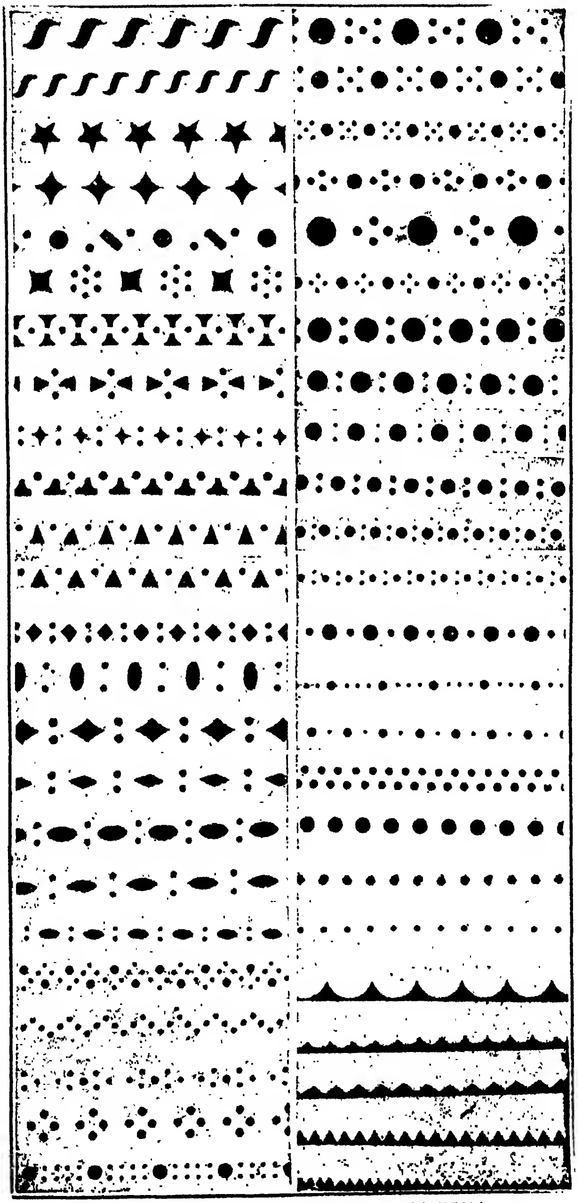
When a new measure comes in or a new style of boot is drawn out, the pattern-maker has to calculate how much of the total area of surface represented by these measurements must be apportioned to each part of the boot. These proportions are determined by the design of the boot.

The Fit of Factory Boots. Measurements in the boot factory have been a source of great trouble, the variations in the proportions of feet making fit by a common standard almost a matter of impossibility. In the course of experience, however, a fair approximation has been arrived at, and now the ready-made boot has a chance of being a good fit. Factory managers assert that the ready-made boot fits the average foot just as well as the average hand-made boot, and does not so often misfit, the margin of error in the former being reduced to a minimum by the scientific grading of sizes.

Measurements. The tables [see page 4435] of measurements and notes have been compiled from the experience of one of the largest, if not the largest, boot factories on this side of the Atlantic. Based on a long and wide experience, we think they are reliable and, in some ways, unique.

Machining the Boot-tops. This department of the boot factory has been taken possession of almost wholly by the fair sex. Nor can the productive capacity of the industry be said to have suffered on that account. It has been calculated, from everyday experience, that, in a well-equipped factory, the girls employed in top-making turn out, on the average, forty pairs of tops per head every week. Machines driven at enormous speed perform the work. For every little detail there is a machine or group of machines. Yet skill and keen attention are demanded from the women workers.

Skill Required. The machines are not automatic. A fairly good idea of the ability required may be gathered from the domestic sewing machine. It is a curious fact, and worth noting,



47. STYLES OF LEATHER PERFORATIONS
(B. U. Shoe Machine Co., Leicester

that all our boot-top machinery has been modelled on the principle of the sewing machine. The numerous and dainty details of boot-top making lend themselves to that particular method of treatment. At the present time the trade is probably unique in this respect. Instead of taking the tools and forming them into an automatic group scarcely recognisable, as he has done in other industries, the inventor simply took the tools of the boot-top maker and put them into machinery, so that they might be mechanically driven at more than human speed.

Variety of Machines. This fact has lent itself to another development which may be confusing to the student of the trade. Because the needle, the awl, the punch, the knife, and the hammer are the common property of the human race, it is open to anyone to gear them on to driving inventions, with the result that there are many different machines for every conceivable detail of boot making, and for some parts the number runs into high figures. After having mastered one machine in a factory, the worker may find herself confronted by a form of machine utterly unfamiliar. This need cause no dismay. The difference is more apparent than real, and in a few hours, or at most days, the new machine will have become as familiar and easily worked as the old.

Skiving. When making boots by hand, we saw how carefully the pieces to be joined were thinned off, so as to make the point of contact as unobtrusive as possible. In the factory, skiving is even more imperatively required, because neatness is one of the special merits of machine production. The skiving blade [see 31, page 4017], which is all that we need attend to, is a flat piece of sharp steel set horizontally on a spindle working above an automatic feed. Lay in the vamp, and immediately the edged disc begins to shave away the leather. Almost while you look the work is done. The circular blade runs at the rate of 1,000 revolutions a minute. One thing is noteworthy in this skiver. No matter how fine the workmanship of the hand worker, some little difference is apt to come in between one skiving and another on the boot-top; but this machine automatically gives the same breadth of skive at all times. Every part of the upper is skived alike. This part of the work done, the stuff is passed on to the sewers.

Sewing. The up-to-date factory has nothing but the new, swift model of sewing machine. Occasionally, however, the worker may be called upon to use the older kinds. Those old-fashioned machines were built under a mistaken idea; it was supposed that heavy machines only could do heavy work. Clumsy things they are, with arms like those of hydraulic riveters, and a grip strong enough to hold down the plate of an Atlantic liner. When working one of these machines, the tension of the thick thread should be specially attended to, because the stitch may be loose if it be left slack, and the whole mechanism may be made to jump if the tension be too tight. For strong boots, made in imitation of hand-mades, those old machines are still useful. For the modern machines mostly used, direction is hardly needed. The worker lays in the work and the machine does the rest. This machine, on which a pile of plain uppers are being sewn, has one needle, and makes a single row of stitching forward, and doubles the row by bringing back the seam. Another group of machines do double rows at once with two needles working at the same time, locking the two threads within the cords from two shuttles.

Difference in Ability. No one ought to imagine that machining boot-tops is easy work. The mechanical appliances are wonderfully perfect, but the human factor can never be eliminated. Side by side, working the same kind of machine, driven by the same motive power, the output of workers differs widely. Of two girls, both equally conscientious, the abler will take 20 per cent. more work out of a machine than her less expert neighbour. Where simple processes are constantly repeated, little delays amount to large losses in the aggregate. Delays arise from inattention to the setting of the seam, careless management of the spools and threads, and too frequent changes of work. The last cause of delay is a matter of management, but the others, and many too small for special mention, lie in the power of the worker.

Seam Finishing. When the bootmaker has sewn a seam, he taps it down level with his hammer. Machine-sewn seams are also rough and obtrusive, and inventive genius has given us quite a number of seam finishers. One form is directly imitative of the hand hammer, with a hammer head set on the end of an arm driven by power; another is a wheel under a spring block, which presses the seams with a rubbing motion; and others combine the two principles, with varying degrees of success. All the models are simple and easy to work, and three or four kinds may be used, the one being regarded as specially good for one purpose, and the others for work of differing classes. Most generally applicable, and most favoured, is the mechanical hammer. Vibrating at the rate of 1,200 beats a minute, the hammer does the work rapidly and prettily. Lay the seam neatly on the block, and let the hammer play upon it while drawing it round. We need hardly say that the operator's intelligence is called upon to some extent in working this machine. Stitches tightly drawn, or hard threads, may be pulled asunder if provision is not made for vibration; but the differences can be readily adjusted by the exercise of a little common-sense.

Seam Rubbers. For light tops, ladies' kid and fancy boots, the seam rubbers are probably the safest. These contrivances are certainly very finely adjusted, and work prettily. One of the best seam-rubber machines has a solid wheel running under a fixed disc, dependent on springs adjustable to any pressure, and therefore fitted to meet the variations in the thickness of the leathers. All the working parts are in sight, and can be operated upon by a young worker.

Bagging. Another small auxiliary of the sewer is the bagging machine. When the linings have been joined to the tops the joints are round and slack. Flaps of button boots are simply

TABLES OF MEASUREMENTS FOR ALL SIZES OF BOOTS

4-FITTING, MEN'S.

Length of Last in Sizes.	Length of Last in Inches.	Joints Measurements.	Instep.	Heel.	Ankle.
5	10	$8\frac{1}{2}$	$8\frac{7}{8}$	$12\frac{5}{8}$	$8\frac{1}{8}$
6	$10\frac{4}{12}$	$8\frac{3}{4}$	$9\frac{1}{8}$	$12\frac{7}{8}$	$8\frac{3}{8}$
7	$10\frac{8}{12}$	9	$9\frac{3}{8}$	$13\frac{1}{8}$	$8\frac{5}{8}$
8	11	$9\frac{1}{4}$	$9\frac{5}{8}$	$13\frac{3}{8}$	$8\frac{7}{8}$
9	$11\frac{4}{12}$	$9\frac{1}{2}$	$9\frac{7}{8}$	$13\frac{5}{8}$	$9\frac{1}{8}$
10	$11\frac{8}{12}$	$9\frac{3}{4}$	$10\frac{1}{8}$	$13\frac{7}{8}$	$9\frac{3}{8}$
11	12	10	$10\frac{3}{8}$	$14\frac{1}{8}$	$9\frac{5}{8}$

NOTES. The sizes range from 5 up to 11. We give length of foot in sizes and the length of foot in inches. We then follow on giving joints measurements, instep and heel and ankle measurements.

(A) A size equals $\frac{4}{12}$ in. in length.

(B) A fitting equals $\frac{1}{4}$ in. small and large.

(C) Girth measure from size to size equals $\frac{1}{4}$ in.

(D) Width of bottom of last from size to size and fitting to fitting, $\frac{1}{12}$ in.

(E) Extension of last over the length of foot: Square toes, 2 size equals $\frac{8}{12}$ in.; medium toes, $2\frac{1}{2}$ size equals $\frac{10}{12}$ in.; spike toes, 3 size equals $\frac{12}{12}$ in.

4-FITTING, LADIES'.

Length of Last in Sizes.	Length of Last in Inches.	Joints Measurements.	Instep.	Heel.	Ankle.	Leg, 6 in. high.
2	9	$7\frac{3}{4}$	8	$11\frac{3}{4}$	$7\frac{1}{2}$	$8\frac{1}{2}$
3	$9\frac{4}{12}$	8	$8\frac{1}{4}$	12	$7\frac{3}{4}$	$8\frac{3}{4}$
4	$9\frac{8}{12}$	$8\frac{1}{4}$	$8\frac{1}{2}$	$12\frac{1}{4}$	8	9
5	10	$8\frac{1}{2}$	$8\frac{3}{4}$	$12\frac{1}{2}$	$8\frac{1}{4}$	$9\frac{1}{4}$
6	$10\frac{4}{12}$	$8\frac{3}{4}$	9	$12\frac{3}{4}$	$8\frac{1}{2}$	$9\frac{1}{2}$
7	$10\frac{8}{12}$	9	$9\frac{1}{4}$	13	$8\frac{3}{4}$	$9\frac{3}{4}$

Remarks as No. 1.

Same notes apply as on No. 1—A to D.

(E) Extension of last over the length of foot: Square toe, $1\frac{1}{2}$ size equals $\frac{6}{12}$ in.; medium toe, 2 size equals $\frac{8}{12}$ in.; spike toe, $2\frac{1}{2}$ size equals $\frac{10}{12}$ in.

4-FITTING, BOYS'.

Length of Last in Sizes.	Length of Last in Inches.	Joints Measurements.	Instep.	Heel.	Ankle.
7	$6\frac{4}{12}$	6	$6\frac{3}{16}$	$9\frac{7}{16}$	$5\frac{7}{16}$
8	$6\frac{8}{12}$	$6\frac{3}{16}$	$6\frac{6}{16}$	$9\frac{10}{16}$	$5\frac{10}{16}$
9	7	$6\frac{6}{16}$	$6\frac{9}{16}$	$9\frac{13}{16}$	$5\frac{13}{16}$
10	$7\frac{4}{12}$	$6\frac{9}{16}$	$6\frac{12}{16}$	10	6
11	$7\frac{8}{12}$	$6\frac{3}{4}$	7	$10\frac{3}{8}$	$6\frac{1}{8}$
12	8	7	$7\frac{1}{4}$	$10\frac{5}{8}$	$6\frac{3}{8}$
13	$8\frac{4}{12}$	$7\frac{1}{4}$	$7\frac{1}{2}$	$10\frac{7}{8}$	$6\frac{5}{8}$
1	$8\frac{8}{12}$	$7\frac{1}{2}$	$7\frac{3}{4}$	$11\frac{1}{8}$	$6\frac{7}{8}$
2	9	$7\frac{3}{4}$	8	$11\frac{5}{8}$	7
3	$9\frac{4}{12}$	8	$8\frac{1}{4}$	$11\frac{7}{8}$	$7\frac{1}{4}$
4	$9\frac{8}{12}$	$8\frac{1}{4}$	$8\frac{1}{2}$	$12\frac{1}{8}$	$7\frac{3}{4}$
5	10	$8\frac{1}{2}$	$8\frac{3}{4}$	$12\frac{3}{8}$	8

(A) A size equals $\frac{4}{12}$ in. in length.

(B) Girth measurement from size to size, $\frac{3}{16}$ in. for 7 to 10; girth measurement from size to size, $\frac{4}{16}$ in. for 11 to 1; girth measurement from size to size, $\frac{4}{16}$ in. for 2 to 5.

(C) Width of bottom of last from size to size, $\frac{1}{16}$ in. for 7 to 10; width of bottom of last from size to size, $\frac{1}{12}$ in. for 11 to 1; width of bottom of last from size to size, $\frac{1}{12}$ in. for 2 to 5.

(D) Extension of last over the length of foot: Square toes, $1\frac{1}{2}$ size equals $\frac{6}{12}$ in.; medium toes, 2 size equals $\frac{8}{12}$ in.; spike toes, $2\frac{1}{2}$ size equals $\frac{10}{12}$ in.

4-FITTING, GIRLS'.

Length of Last in Sizes.	Length of Last in Inches.	Joints Measurements.		Heel		Leg.
	$6\frac{4}{12}$		$6\frac{3}{16}$	$9\frac{3}{16}$	$5\frac{11}{16}$	[illegible]
	$6\frac{8}{12}$	$6\frac{3}{16}$	$6\frac{6}{16}$	$9\frac{6}{16}$	$5\frac{14}{16}$	$6\frac{10}{16}$
	7	$6\frac{6}{16}$	$6\frac{9}{16}$	$9\frac{9}{16}$	$6\frac{1}{16}$	$6\frac{13}{16}$
	$7\frac{4}{12}$	$6\frac{9}{16}$		$9\frac{12}{16}$	$6\frac{4}{16}$	7
	$7\frac{8}{12}$	$6\frac{3}{4}$		10	$6\frac{1}{2}$	$7\frac{1}{2}$
	8	7	$7\frac{1}{4}$	$10\frac{1}{4}$	$6\frac{3}{4}$	$7\frac{3}{4}$
	$8\frac{4}{12}$	$7\frac{1}{4}$	$7\frac{1}{2}$	$10\frac{1}{2}$	7	8
	$8\frac{8}{12}$	$7\frac{1}{2}$		$10\frac{3}{4}$	$7\frac{1}{4}$	$8\frac{1}{4}$

(A) A size equals $\frac{4}{12}$ in. in length.

(B) Girth measurements from size to size, $\frac{3}{16}$ in. for 7 to 10; girth measurements from size to size, $\frac{4}{16}$ in. for 11 to 1.

(C) Width of bottom from size to size, $\frac{1}{16}$ in. for 7 to 10; width of bottom from size to size, $\frac{1}{12}$ in. for 11 to 1.

(D) Extension of last over the length of foot: Square toes, $1\frac{1}{2}$ size equals $\frac{6}{12}$ in.; medium toes, 2 size equals $\frac{8}{12}$ in.; spike toes, $2\frac{1}{2}$ size equals $\frac{10}{12}$ in.

4-FITTING, CHILDREN'S.

Length of Last in Sizes.	Length of Last in Inches.	Joints Measurements.	Instep.	Heel.	Ankle.
3	5	$5\frac{5}{16}$	$5\frac{7}{16}$	$8\frac{6}{16}$	$5\frac{14}{16}$
4	$5\frac{4}{12}$	$5\frac{8}{16}$	$5\frac{10}{16}$	$8\frac{9}{16}$	$6\frac{1}{16}$
5	$5\frac{8}{12}$	$5\frac{11}{16}$	$5\frac{13}{16}$	$8\frac{12}{16}$	$6\frac{4}{16}$
6	6	$5\frac{14}{16}$	6	$8\frac{15}{16}$	$6\frac{7}{16}$

(A) A size equals $\frac{4}{12}$ in. in length.

(B) Girth measurement from size to size, $\frac{3}{16}$ in.

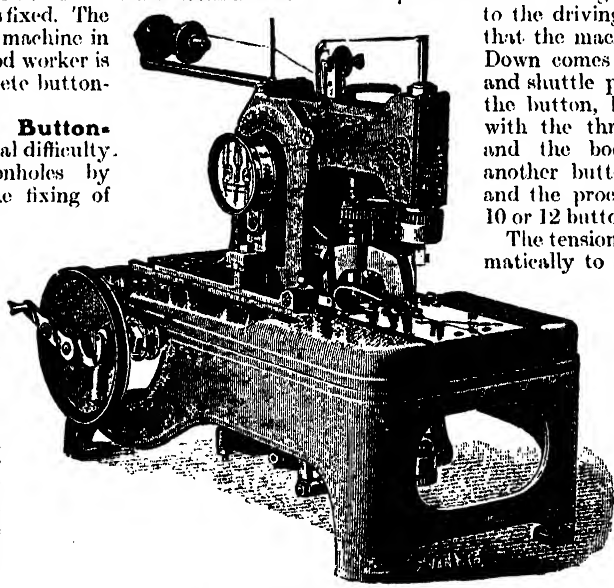
(C) Width of bottom from size to size, $\frac{1}{16}$ in.

(D) Extension of last over the length of foot: Square toes, 1 size equals $\frac{4}{12}$ in.; medium toes, $1\frac{1}{2}$ size equals $\frac{6}{12}$ in.

bags sewn on the inside and turned out. To make the flaps solid and flat, the seams must be pressed somehow. Here we have a machine equal to the need. It is double-jawed. On the under jaw is a long finger of electroplated metal, and a solid round disc sits in the upper jaw. Place the flap on the top of the finger, and bring the upper jaw down. The finger vibrates on the seam inside, and the disc rolls on the outside, the pair between them reducing the bag to an apparently solid piece of leather with a fine edge.

Buttonholing. Button boots are produced in large quantities, of all sizes, by the factories. In fact, the popularity of that class of boot is almost wholly due to the cheapening effect of machinery. Anyone who looks at a buttonhole can readily realise how laborious and costly the making of buttonholes in leather must be. Our problem was to find a machine which could make buttonholes in a satisfactory way. For a long time the machines offered to us, in good faith no doubt, proved miserable failures, producing botched work. At last, however, the problem was solved, and now we have machines which both cut and sew buttonholes in very fine style. The machine with which we are most familiar is the "Reece" [48]. A die knife cuts out the hole. From spools set on the head of the machine the two threads come down into the oscillating needles which work round the hole. When the end of the hole is reached, the machine automatically stops sewing, and fixes in the ends of the threads. On the head of the machine the tension regulator is fixed. The production of this machine in the hands of a good worker is about 6,000 complete buttonholes a day.

Finishing Buttonholes. One special difficulty in making buttonholes by machinery was the fixing of the ends after the buttonholes were sewn. As everyone knows, the sewing machine always leaves open threads at the end of a seam, and these must be tied or cut away. The method adopted was to run a bar of sewing along the flap at the bottoms of the buttonholes. This, however, added a pattern to the flap which was not desired. As we have said, the newest forms of machine have overcome the trouble, but, as a rule, at some expense of neatness. An ingenious man conceived and invented a machine that could take a stitch in one ply on a flap while leaving the other one untouched. With this contrivance the bar to fix the ends of buttonholes can be made on the underside of the flap and out of sight.



48. HIGH-SPEED REECE BUTTONHOLE MACHINE

(B. U. Shoe Machine Co., Leicester)

Sewing on Buttons. Men not very old in the trade can remember well the many vigorous attempts made to devise a mechanical fastening for buttons. Rivets, flat discs, long wires like miniature hairpins, and many other devices were tried but the public unmistakably showed a constant preference for the hand-sewn button. No wonder, for the flap of a buttoned boot with one of those sets of fasteners on felt like the sole of a heavily-hobbed boot. But our machinists were not to be beaten. Small as the matter may seem, there is a large amount of money in it. The happy idea of using the form of the sewing machine for the button fastener was struck, and then the problem was solved, not all at once, but by successive attempts, each one improving on the last. What improvements may yet be made we do not undertake to predict, but the present form of machine serves our purpose fairly well. The plan of this machine is an arm and stand extending at right angles from the operator [49]. On the top of the arm is a hopper from which a channel leads down in front of the needle. Resting on the stand is the gripper, which keeps the work in place and guides it automatically from button to button.

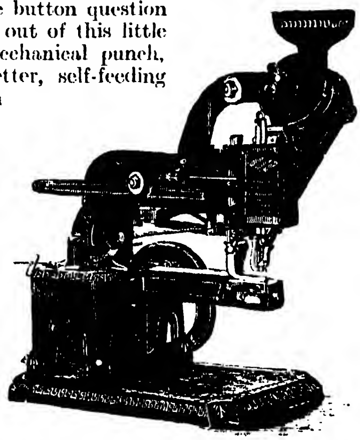
A Perfect Machine. The inventor has done his work well. So far as the worker is concerned, the machine is simple. We put a few gross of buttons into the hopper, and clamp the work upon the stand. Bring the driving belt on to the driving wheel, and watch that the machine does its work. Down comes a button; needle and shuttle play over the eye of the button, linking it firmly in with the thread; they retreat and the boot-top moves on; another button comes in place, and the process is repeated till 10 or 12 buttons have been fixed. The tension adjusts itself automatically to any grade of work, from French kid to heavy grain leather, and each button is secured independently. With the button-sewing machine a thousand boot-tops can easily be disposed of in a day. We have heard objection made to the single thread, and the criticism has some reason in it. We will gladly learn another and better machine, if the invention comes along.

Punching and Eyeletting. The staple of our trade is the lacing boot. Fashions come and go; but for the past fifty years the lacer has been the stand-by. In the average

boot there are 16 holes; in boots of the better class six of these holes are filled with eyelet hooks and ten with eyelets. For a man working by himself, making three pairs a week, this does not mean very much; he can punch them in a short time, and think little about it. But when you have charge of a large factory sending out from twenty to thirty thousand pairs a week, two-thirds of them lacing boots, then the punching and eyeletting becomes a very serious item. It means the employment of twenty men for that small matter only, and smart men, too. But the genius that solved the button question was quite equal to helping us out of this little trouble. First we had the mechanical punch, then its companion the eyeletter, self-feeding and capable of being driven by power; next came a combination of the two, and lastly the automatic punching and eyeletting machine. All four kinds are still on the market, made by various firms. Factories of small dimensions, or factories chiefly engaged in producing ladies' and childrens' boots, can very well get along with the smaller machines, because eyeletting is never a large business with them.

Small Machines. The small punches and eyeletters are simply die-stamping machines with, in the one case, a punch, and in the other an eyelet holder instead of the die. With these machines two operators can produce between them from 3,000 to 4,000 finished eyelets in an hour, though the speed on the working day may be a little less.

Factory Eyeletting. The automatic eyeletter is the contrivance with which the work of the factory is done. Here, again, the sewing-machine idea is seen in operation, with additions. A small box tray on the top holds the eyelets, and from it a channel runs to the nose of the punch. As the punch comes down and retreats, the eyelet setter follows its action as quickly as lightning, and the eyelet is done. By an automatic motion, the top is moved the space, ½ or ¼ in., between the holes, and the next hole is made and eyeletted. The operator's duty is to put the top in position, lift it away when finished, and guide the work, while keeping his foot on the foot lever for emergencies. By mastering this machine, the worker can punch and eyelet 10,000 holes per hour.



49. STANDARD BUTTON-FASTENING MACHINE

Eyelet-hooks. Rather more difficult is the hook-setting machine, and it works more slowly, though on the same principle as that just described. We have seen several kinds of these at work, and they perform very well, considering the difficulty to be overcome. A hook is an eyelet with a fixed hook lying over it; the drive home differs, therefore, from that of an open eyelet; but the difference has been negotiated by a change in the punches.

Linings. We have left linings out for the moment. It depends on the kind of boot when the linings are brought in. Say that it is a batch of ladies' boots we are doing. Sometimes these are lined with fine morocco, but the kind most commonly in demand are lined with good cotton drill, edged with chamois, morocco, or other fine leather.

The linings are cut with the uppers, and sent into the machine-room at the same time; but they are put together in a different way on a separate set of machines. On the folders, neat little fingers working under a machine arm turn over and press down the edges of facings and heads of the linings. Next the parts are joined together on ordinary sewing machines, fronts and backs being lightly seamed into unity. Now the upper or top, without the vamp or front, comes round and meets the lining. They are put edge to edge, the insides coinciding, and sewn round. When finished and turned right-side out, the top and lining are joined, and not the vestige of a seam appears.

An economy is effected in this way, for you can attach the vamp to the lining at the same time as you are attaching the vamp to the rest of the upper. If it be desired to put several rows of stitching on the vamp, the upper lining can be turned back after being joined.

The edgings of the linings are beaded and bagged in the same way as the button flap, before described.

When the top is completed, it is prepared for the lasting, and sent in batches to the bottoming department.

Continued

Group 7 BANKING 4	THE BANK'S BOOKKEEPING

Group 7

BANKING

4

Continued from page 4295

THE BANK'S BOOKKEEPING

Contingent Liabilities and Assets. The Balance-sheet and its Items. General Ledger Accounts. Bills

By R. LAING

Bullion Reserve and Note Issue. The care of the bullion reserve and note issue will also be given to certain special officials. The work attendant on the first will not be of great amount (the needs of the bank at varying seasons becoming well known in course of time), the main object of the officials concerned being to curtail as much as possible the expense of the transfer of coin from one office to another.

The note issue claims more attention. Great care must be taken in the first place to prevent forgery, the principal checks against and means of discovery of which are the watermark, colour printing, designs on the back of the note, secret marks, and the use of, say, alternate numbers only. The number of notes printed is agreed with that of the blank sheets delivered, and, as an additional check against fraud, they may be signed before issue by some official below the lithographed signature, although such a practice is not universal. The custom with regard to re-issue also varies. The notes of the Bank of England are never re-issued, but those of the Scotch banks are paid out again and again. The records of the issue and destruction (usually by fire) of the notes are kept by this department. The destruction or loss of a bank-note by the holder is equivalent to the cancelling, without payment, of a liability of the bank, and the profits accruing in this connection to banks issuing small notes are—there is reason to believe—of considerable amount. The amount of a partially, or wholly, destroyed note may, however, be paid upon a declaration being made, and a satisfactory indemnity given.

The work of the head office, and more especially that undertaken by the managers and chief officials, includes, of course, the arrangement of general business, decisions on questions of policy, and, generally, the oversight of all large transactions, in conjunction with the board of directors. If the bank be a joint-stock company, the usual secretarial duties will be carried on at the head office, and the necessary returns to Government made up there.

Agency Business. The head office will further look after the accounts between the bank and the various correspondents, the ledger accounts being posted from the advices or returns received from the branches. If, in the course of business, it is found that the community in any locality where the bank has a branch have large and frequent transactions with any other district, or with some foreign country, arrangements will be made with another bank situated there, to their mutual advantage, both direct and indirect. Such arrangements are usually detailed in a correspondents' book, any additions or alterations being intimated by circular. The arrangements come to by the contracting banks may be expressed in a multitude of ways, while the consideration will be determined by their relative needs. For example, a London bank acting as correspondent to a small country or foreign bank confers on it a much greater benefit than it receives, a fact that will influence the terms of their contract. The consideration may take either the form of a stipulation to keep a certain balance, or of a commission on the whole, or on certain of the transactions. An account with a foreign bank requires to be kept in two currencies, one in sterling to balance with the bank books, and the other in foreign currency to agree with the accounts of the foreign bank.

If the trade of any small town does not warrant the establishment of a separate office, a branch may be opened (doing business during the whole or a part of the week) under the charge of some subordinate official of a neighbouring office, the manager of which is responsible to the head office for the transactions of both branches.

The Balance-sheet. The balance-sheet is invariably drawn out in a form similar to that adopted for all commercial undertakings. For the sake of clearness, an abbreviated example is given below. The special entries requisite for its completion are dealt with in the course on Bookkeeping.

The first two items on the liabilities side represent the capital and the reserve fund of undivided profits, forming the total due to the shareholders. As this amount forms the last charge on the bank's assets, it is subject, in the event of liquidation or other winding-up to a reduction equal to the sum by which that actually realised by the assets falls short of the amount at which they appear in the balance-sheet. Such a reduction may be nullified, or even transformed into an addition, by the existence of the hidden reserve afterwards dealt with.

Reserve and Contingency Fund. The investing and the depositing public look to a steady increase of the reserve fund, while,

Dr.			Cr.
Capital	£1,000,000	Cash on hand and with bankers ..	£2,500,000
Reserve fund ..	700,000	Money at call and short notice ..	1,550,000
Deposits	13,000,000	Investments ..	1,500,000
Drafts and transfers	30,000	Bills and Loans ..	9,630,000
Notes issued ..	450,000	Premises	200,000
Acceptances and endorsements ..	120,000	Acceptances and endorsements ..	120,000
Profit and loss ..	200,000		
Bills rediscounted, £750,000, of which £500,000 has since matured, and run off.	£15,500,000		£15,500,000

on the other hand, a reduction in the amount would have a most disastrous effect on their confidence. In consequence, no sum is ever taken from such a fund, save in most exceptional circumstances, and to enable this course to be carried out, a *second* (or *hidden*) *reserve* is maintained, to which sums which would otherwise pass through the public reserve are placed, and withdrawn as occasion demands.

This second fund, in making up the balance-sheet, may either be included in the current accounts or written off the assets.

The deposits are usually included in one total. Drafts and transfers follow, and represent the aggregate amount of these which have not yet been settled by the bank, either by cash payment or by a credit in account, while the sum shown against note issue is the actual amount in the hands of the public.

The item "acceptances and endorsements" is only a contingent liability, and is balanced by an entry for a similar amount on the assets side. The bank has given the security of its name to this extent, but in the event of making any payment it will look to its clients for a refund. The business represented by the two entries has been already referred to.

The treatment of profit and loss account is similar to that generally adopted. The amounts which are placed to the credit of this account will represent interest on loans, discount and commission of any nature, returns on investments, rents, bad debts recovered, etc., while the amounts withdrawn will include interest on deposits, rediscount (if any), commissions, stationery, rent, taxes, salaries, expenses of note issue (if any), bad debts, depreciation, etc., and, in addition, any sums transferred to reserve or dividend accounts.

The amount of rediscounts is shown as a contingent liability, if the bank is in the habit of rediscounting.

Assets. Assets are divided, in varying degrees of detail, into different classes according to the ease with which they can be converted into cash or its equivalent, any item easily convertible into cash being termed a liquid asset. Cash on hand (coin, bullion, and notes of other banks) may or may not be coupled with the balances deposited with other institutions. Money at call or short notice with brokers follows, and the proportion shown in the balance-sheet between the liquid assets and the liabilities to the public is subjected to the closest scrutiny.

Cheques and similar documents in course of post may be included in the cash total or incorporated in the amount shown against loans. The figure at which the customary investments in first-class stocks is entered is the one at which they stand in the bank books. This will be found to be very much below the current market value, the securities, when bought, being written down to a figure to which it is thought they will in the ordinary course never fall. Before the recent enormous fall in Consols it was very customary to value them at 90, but the unexpected course of events has rendered a lower figure necessary. It is usual to give in the balance-sheet a somewhat detailed statement of the securities held. Bills discounted and loans may be either given in one sum or in detail.

Bank Bookkeeping. In this section it is assumed that the reader is either possessed of some practical acquaintance with the above, or has a knowledge of the system used in mercantile business. If the contrary be the case, some study of ordinary bookkeeping will be necessary, after which the special points of that applicable to banks will present no difficulty. One essential difference is the absence of stock and manufacturing accounts, and the attendant periodical stocktaking. The material property possessed by any bank is, compared with the total amount of its resources, comparatively small, seldom undergoes any change, and is held at a figure much below its real value.

Each entry in bank bookkeeping is a cash book or journal one, nothing corresponding to the mercantile day and invoice books being in use. A debit entry in a bank ledger has the effect either of: increasing a debt due to the bank, decreasing a debt due by the bank, increasing the amount of an account representing a material or similar asset, or ultimately forming a charge on profits; while a credit entry has the effect of either: decreasing a debt due to the bank, increasing a debt due by the bank, diminishing the amount of an account representing a material or similar asset, or ultimately forming an addition to profits.

We consequently find in all bank offices two books—which may be termed the general cash book (or journal) and the general ledger—through which all transactions pass, either briefly or in detail, the subsidiary books being divided into these classes:

1. Cash books.
2. Cross entry books.
3. Registers (with or without running numbers).
4. Ledgers.
5. Books partly registers and partly ledgers.
6. Books kept in diary form.
7. Books recording balances and other particulars.

General Ledger. The table given on the next page represents the balances shown in an imaginary general ledger, kept at a head office (the shillings and pence being omitted).

The Bank's Account. In the example given the bank is supposed to have three branches, a separate account being kept by the head office for the transactions referring to each of them. At each of the branches consequently three accounts will also be kept under this heading. This method is best adapted to a foreign or colonial bank with few and widely spread branches, as it enables each particular branch to ascertain at any time the position of its account with any other office, and allows of the inter-branch accounts being checked by the offices concerned.

In the case of a large home bank there is no necessity to know the balance of the transactions between any two branches, and the entries will, in consequence, be passed through

Dr.		Cr.
£		£
	Bank's account	
	Branch A	7,123
97,628	Branch B	
8,721	Branch C	
	Current accounts	1,203,767
1,664,912	Loans	
	Deposit accounts	403,698
	Deposit receipts	129,812
287,693	Local bills discounted	
284,872	Bills received (or remitted)	
1,272	Bills past due	
777	Stamp account	
	Commission account	12,302
	Interest account	36,202
20,681	Charges account	
	Bills for collection	80,721
80,721	Collection bills received	
	Acceptances and endorsements	293,601
293,601	Acceptances and endorsements account	
	Client	
	Letters of credit and circular notes	1,928
	Capital	1,000,000
	Reserve fund	400,000
	Contingency fund	210,000
	Notes issued	600,100
	Dividend account	9,527
	Unclaimed dividends	63
	Pension fund	90,000
	Profit and Loss account	20,918
	Suspense	13,701
	Agency accounts :	
1,921	Bank A	
	Bank B	16,702
	Bank C	2,163
900,000	Investments	
154,000	Premises	
200,000	Money at call and short notice	
299,777	Cash at bankers	
235,752	Cash	
£4,532,328		£4,532,328

one account. The weekly returns from the branches of this account will, in such a case, be audited by the head office, and may be divided into sections, bearing either the names of the corresponding branches or of the various classes of business. The first method admits of an error once passed being perhaps more easily discovered, but the second allows of a summary of the different classes of outstanding entries being more readily made up. The amalgamation into one account in the example given would, of course, result in the substitution of the following for the first three balances:

Dr.	
£99,226	Bank's Account.

It will be apparent that the balances in the head office general ledger do not include the whole business of the bank, the £129,812 shown against Deposit Receipts being the total outstanding of those issued by the head office only. The business current at the other branches is represented only by the balance or balances at the Bank's Account.

In addition to the Bank's Account, the accounts which are common to the general ledger at all branches include current accounts (the balance of which represents the total of the accounts in credit less the amount of overdrafts, or vice versâ), loans, deposit accounts and deposit receipts, the balances shown corresponding with the current outstandings.

Discounted Bills. It is the practice to place the full amount of a bill, when discounted, to the debit of some bill account, crediting the discount at the same time to an interest account. Sums received in payment are credited to the bill account, and should the draft not be duly met at maturity the amount will be transferred to *Bills Past Due Account*, the balance of which agrees with the total of unpaid past due discounted bills in the hands of the bank. A doubtful overdraft is not treated in this manner, but is allowed to remain in the relative ledger, although an amount has actually been set aside against it. A distinction is made between bills payable locally and those domiciled elsewhere, the *Local Bills Discounted Account* agreeing with the amount of this class of paper in hand.

Two distinct methods of dealing with the bills not payable locally are in vogue. The transfer of the amount of the bill from the books of the discounting office to those of the office to which it is forwarded (for presentation for payment on due date) may be made either at the time of discount or at maturity, the draft disappearing as an asset from the books of the discounting branch when such an entry is made. The bill will, if the amount be debited at the time of discount, appear during its currency as an asset at the *Receiving branch*, and an account similar to that for Local Bills Discounted will be kept by it for *Discounted Bills Received from other Offices*. If the second method is adopted, the discounting branch will keep a *Bills Discounted and Remitted Account*, which will correspond with the amount of bills discounted (other than local), which have neither been advised as paid or returned unpaid. *Nominal* accounts may be kept by the remitting branch, in the first instance, and by the receiving office, in the second.

Nominal Accounts. When it is considered desirable to know the amount at any time of any particular class of business, which does not at the time constitute an actual liability or asset at the office in question, two accounts will be opened in the general ledger, the one to give the total outstanding and the other to balance the amount shown in the former. Two instances are given in the specimen general ledger balance—the first relating to bills received by the head office for collection which have not been discounted. On such a bill being received an entry is passed increasing the balances of the two accounts to the same extent, and on any bill being paid or returned the balances are reduced by an equal sum. The same procedure applies to the *Acceptances Account*, which shows the total contingent liability of the bank and contingent liability of its clients in this connection. As no book-keeping check exists on such accounts special care requires to be exercised with regard to them.

The Stamp Account. The *Stamp Account* shows the value of stamped forms as yet unsold to the bank's clients. The cheque forms, etc., are not stamped immediately after being printed, but only when required to replenish the stock in hand, and, in consequence, the balance of this account will never be of very great amount.

Letters of credit and circular notes represent the amount of such documents issued. The balance of a *Circular Notes Account* kept at a branch appears on the opposite side of the ledger, the head office, in forwarding a supply to the branch, treating the latter as if it were a customer, and debiting the branch with the full value. An account is accordingly opened by the branch and kept on similar lines to its local Bill Account. On any note being issued its amount is deducted from the branch account, the account kept at the head office being reduced on payment being made by it to the ultimate holder of the note. The foregoing accounts may be added to, or divided, to suit the convenience of any particular office or system.

Profit and Loss Accounts. Profit and Loss Accounts are represented in the example given by interest, commission and charges, but these may be subdivided to show the amounts relating to each particular class of business, a result that may also be obtained by ruling the portion of the ledger used in the manner indicated on this page (the interest account being dealt with).

The columns shown (increased to cover all classes of transactions) are summed and balanced periodically, and give the information required.

The remaining accounts (with the exception of cash) come under the heading of *Accounts Peculiar to the Head Office.* The Cash Account simply represents the cash on hand, including the bank's own notes in the cashier's tills. Capital, Reserve Fund, and Contingency Fund require no explanation. Notes Issued represents the total handed to the cashiers or sent to the branches which have not returned for destruction, the amount including all notes held at any office. *Dividend Account*, the balance of which is transferred after a certain time to the *Unclaimed Dividend Account*, shows the total of the current dividend warrants outstanding.

To Profit and Loss Account the balances of the profit and loss accounts at all the offices are transferred at each balance, while it is reduced by the sums put to dividend, reserve, contingency, premises, investment, pension, or other accounts. If any amount is laid aside to provide the working of a pension scheme it is placed to a special account kept at the head office. *Suspense Account* is dealt with under balance work. The other accounts have already been referred to, and subsidiary books are dealt with subsequently.

Date.	Dr.	Cr.		Balance.	Deposit Accounts	Deposit Receipts.	Sundries.	Overdrafts.	Loans.	Discounts.	Sundries.
Dec. 31			Cr.	—							
Jan. 1	30 2 5	32 9 5	Cr.	2 7 0	1 2	30 1 3		17 3	11 2 6	20 9 8	
Jan. 2	15 7 11	10 7 2			2 3 7	12 17 6	6 10	8 3		9 18 11	
	45 10 4	42 16 7	Dr.	2 13 9							

With a view to convenience, some accounts other than in the name of clients may be kept in the Current Account Ledgers instead of in the general ledgers. "Unclaimed Balances"—the account to which all sums left unclaimed for a certain time are transferred—is invariably one of these, while accounts for the temporary disposal of money which cannot be finally dealt with on receipt may be treated similarly—*e.g.*, an amount transferred from another office to await instructions may be placed in such an account.

Cash Books. The General Cash Book may either be written up from the subsidiary books, from vouchers, or partly from one and partly from the other, all cross entries between departments (which in a large office will be numerous) being, of course, eliminated. It may either be written up concurrently with the subsidiary books or on the following day, the entries being collected and arranged in the order most convenient, while the book may be closed off, either daily or weekly.

In large offices, the cashiers may be divided into two classes—receiving and paying. The cash books of the first simply record the sums paid in during the day, the total being agreed at the close of business with that of the relative waste book.

The latter is a very wide book, in which the particulars are entered in a manner similar to that shown on this page.

From Whom Received.	Drawer	Bank.	Cash.	Notes.	Clearing.	Walks.	House Debits.†	Totals.
J. Jones	10,701 * A/B							
..	A. Thomas	Glyn	20	10	30	..	..	60
C. Forsyth	W. Smith ..	..	10	..	..	..	20	30
W. Watson	A. Jenkins ..	London and County	10	..	100	..	..	..
	..	Islington						
..	G. Howard ..	National India	..	..	..	10	..	120
* Number of Note. † Documents drawn on the bank in question.			40	10	130	10	20	210

The columns may be increased and divided, as may be deemed necessary, while the number of particulars given depend on individual practice. The paying cashiers record all sums paid away (mainly cheques drawn on current accounts), the numbers of Bank of England notes paid out being detailed.

Each cashier may deal with the ledger accounts only under a certain letter or letters, while Deposit Receipts, Country, Bill and other business will in all probability be dealt with separately.

The cash book of an official at a small office, however, contains the entries comprising the whole range of business, and in such a case the advantage of a columnar cash book is evident. By means of this any body of entries whose number is large (*e.g.*, those relating to current accounts) may be entered in a special column—the total of which is carried to the outer column at the end of the day—making the discovery of errors a much easier matter.

Cross Entry Books. A large number of books of varying form will be kept by the different departments to record the entries passed by them, the bill entries going perhaps into one, the correspondence remittances into another, and so on, although arrangements may be made to enable certain officials, through an elaborate use of vouchers, to deal with all such entries. All given to another branch or bank to cash the cheques of any client to a certain extent should be entered in the ledger, and a similar course adopted with regard to cheques on which an endorsement guaranteeing payment has been placed by the banker, so that, if necessary, the account may be kept at a figure sufficient to cover these outstanding liabilities. A very numerous body of entries (say, dividend warrants) may be detailed in a subsidiary book, and only the total inserted in the ledger.

Checking. The checking of the entries should be done by independent officers, while fraud is further guarded against by an occasional interchange of ledgers. It is usual to extract weekly the balances shown, and to agree the result with the general ledger account, the return of overdrafts being made up from this balance.

Date.	Particulars.	Dr.	Cr.	Sign.	Balance.	Days.	Decimal.	Interest.
				Dr.	16 7 3			
Dec. 31	To Interest	1 0 0		Dr.	17 7 3			
	By Cheque .. .	..	117 7 3	Cr.	100 0 0	..	7,300	
	To Balance	100 0 0						
							5 %	1 0 0
		17,931 2 7	17,931 2 7					
Dec. 31	By Balance	..	100 0 0	Cr.	100 0 0	3	300	
Jan. 3	To 12,731	220 0 0		Dr.	120 0 0			
	" 3	30 0 0						
" 5	" 5	100 0 0		Dr.	250 0 0	2	500	
	By (Cash 100) and Cheques	..	200 0 0	Dr.	50 0 0			

cash and cross entry books may only be used on alternate days, to facilitate, if necessary, the work of checking. The example shown above will show that a bank ledger differs somewhat from the ordinary mercantile form.

In the foregoing example we start the New Year with a balance of £100, £200 being received, and three cheques amounting to £350 being paid, leaving the account overdrawn £50. The balance must be shown at the close of each day, and, if it is an overdraft, must always be preceded by the sign *Dr.* In some banks it is not customary to repeat the sign *Cr.* against every balance when the account is *invariably* in credit. The numbers given are those on the paid cheques, although the names of the parties in whose favour the cheques are made out are in some cases entered.

For convenience in reference, the ledger accounts are arranged alphabetically, while the heading of each account should set forth the security held, the overdraft limits authorised, the names of persons authorised to operate, and so on, the ledger keeper being responsible to see that all cheques paid are in accordance with these particulars. In entering any sum received he should be careful to distinguish between cash and cheques, to obviate the possibility of a cheque, the fate of which has not been received but which is afterwards returned unpaid, being paid against as cash. The particulars of any authority

In an office employing several current account ledgers, two books, ruled in the manner shown below, will be used to record, under the heading of each ledger, the debits and credits referring to it. These books, which are agreed with the current account entries in the cash and cross entry books, allow of each ledger being balanced separately.

Each entry in the deposit receipt register is initialled by the official who signs the relative receipt, a similar practice being adopted with regard to drafts and transfers. The columns in the register for these will provide for date, number, on whose account, in whose favour, paying branch, amount, commission, initials.

Name.	Fo.	A—D	E—K	L—R	S—Z

Bill Registers. The bill registers (which will be divided into various sections) give all particulars regarding bills received from customers, either for discount or for collection, and any documents attached thereto—date of entry, running number, names on bill, date of bill, currency, place of payment, amount, rate and amount of discount, details of documents, etc. In the bills for collection section, the discount columns will be replaced by one in which the date on which payment is received or advised is marked. Bills received to be forwarded to some point, for acceptance and return, may be placed in a separate section.

The entries relating to bills received from other offices do not require to be so elaborate, but the due dates of these and of local bills require to be

very carefully entered in a book kept in diary form (under the date on which they mature), to prevent the presentation for payment being omitted.

Diary. The diary forms, in addition, a convenient method of noting the expiration of a loan, or any other business which will require attention on a certain date. The form given below is one covering several classes of business.

Discount Ledger. The discount ledger is kept to show the total discounts current at any time, the amounts of the bills being debited when discounted and credited when matured, a special account being opened for any client discounting largely, and all miscellaneous items being collected under "sundries." A statement may be made up weekly to balance with this ledger, showing the amount discounted at each rate.

In addition, books in which are recorded the particulars of periodical balances, cheque books sold, cheques and other documents received, with clients' signatures and letter registers, postage books, indexes, files for letters of credit and other authorities, and a multitude of small memo. books in which outstanding matters, particulars of securities, etc., are entered, will be required.

The securities lodged for safe custody are entered under the heading of each client's name, the fullest particulars being given both of the bonds, etc., and of any coupons attached. On delivery being made of any particular document, the receipt on which it appears may be returned, endorsed, and a new receipt for the remaining bonds issued, or the old receipt may be allowed to stand, the entry in question being deleted and a receipt taken from the customer. If the documents are numerous and operations frequent, it is desirable that the client should employ a locked box to which persons bearing authority are allowed access.

The bookkeeping returns from the branches may be divided into two sections—those which refer to local business (deposit receipts, current accounts, etc.), and entries to the bank's account. Every entry in the last requires to be detailed (for head office checking purposes), but the other transactions need only be given in brief form, no useful purpose being served by, say, a long statement of current account transactions.

Balance Work. With a bank possessing a large number of branches scattered all over the country it is clearly impossible for the auditors

Date.	—	Local Bills Discounted.	—	Bills Discounted and Remitted.	—	Discounted Bills Received.	—	Collection Bills Received.	—	Acceptances Due.	—	Customers Acceptances payable in London.	Remarks.
Jan. 1	223	100 1 2	92	20 9 3	83	100 0 0	174	15 1 6	7	150 0 0	719	100 0 0	W. Smith Loan £500, due 7th.
	301	50 5 10	117	16 5 1	127	500 0 0	..	..	..	..	20	67 1 2	J. Thompson Ashanti Coupons due 5th.
											21	1,000 0 0	
„ 2	127	150 0 0	205	90 0 0	100	167 1 9	54	57 1 10	..	..	722	750 0 0	Have Promissory Note No. 18/10 renewed.
			137	10 2 6	..	..	..	..	..	..	3	97 8 2	
			81	410 5 7	..	..	..	..	..	..	614	100 0 0	
											5	500 0 0	

Banks dispensing with waste books will, in addition, use registers giving particulars of cheques remitted.

Pass Books. The pass books are, in a way, distinct from all the other books of the bank, being the only part of the system which is directly subject to the scrutiny of the public. They are, moreover, regarded as the customers' books, the entries being placed on the reverse side to that on which they appear in the bank's ledger, the pass book being similar in form to the bank account kept in the customer's ledger.

The pass books should be written up from the vouchers, and not merely copied from the ledgers, all books in hand being regularly made up each morning to include the transactions of the previous day; and when any book is handed to the customer concerned, a mark to this effect should be placed against the relative balance in the ledger. The practice in Scotland is somewhat different. There the paid cheques are not delivered till the customer has certified the amount to be correct. In England, however, the paid cheques are, on the day following, sorted under the names of the various clients, being either sent with any statements rendered, or placed in a pouch provided in the pass-book cover and delivered when the book is sent for.

to examine all the books personally. In consequence, the signed returns from the other offices are accepted as correct (the periodical inspection from head office supplying the necessary check). The ordinary weekly returns are made up to the night of the balance, and from these the head office is at once able to make up a balance-sheet similar to the usual weekly one.

The balances of the profit and loss accounts at the branches having been transferred to the head office (after closing the books for the half-year), through the bank's account, the only modifications which the balance-sheet subsequently undergoes are on account of the suspense or adjusting entries for interest *due but not applied, etc.* For such entries no further particulars are actually required by the head office, beyond the total amount due at each branch of interest on deposits and loans of rebate on bills discounted outstanding at the time of the balance, etc. In practice, however, the individual amounts of principal and interest or rebate are given against each name. If the current account and deposit account interest is applied on the date of the balance, no adjusting entries will be required on their account.

Deposit Receipts and Ledger Accounts. Some little time before the balance, the decimals and interest calculations in the ledgers are carefully checked to date, and on the evening *previous* to the end of the year or half-year the total amount due on each account is found and entered in the return previously prepared. On the succeeding night after the ledger balance has been agreed, the principal sums are also entered. The interest due on individual deposit receipts is calculated, and the return of outstanding receipts made up before the date of the balance, those paid after insertion being subsequently deleted. The interest on receipts issued during the half-year is calculated on each separate amount (with the assistance of a table, giving the decimal for each day), while that on those which were outstanding at the date of last balance may be arrived at similarly, or by the addition of the amount due for the half-year to that accrued at the last balance, each calculation in the latter method being based on the same decimal. The correctness of the interest calculations may be proved by keeping an account showing the daily balance of deposit receipts, the interest due on which is reckoned in a manner similar to that on ledger accounts. This, added to the amount due at the previous balance, less what has been paid during the year, should equal the sum now due.

Bills Returns. The bills detailed in the Bills Returns may be either bills remitted or bills received, according to the method of keeping the general ledger account. In either case rebate for the time yet to run will be calculated at a rate (usually 5 per cent.) which will more than cover the rate at which discounted, a lower rate than that of discount inflating the current profits at the expense of those for the succeeding period. No interest is calculated on past due bills. These returns, together with any additional ones required by the head office for their own information, having been summed, checked, signed, and despatched, the ledger accounts having been closed and reopened in the usual manner, and the registers ruled off and new running numbers begun, the balance work at the branches may be considered to be finished, all further entries being passed by the head office.

Before passing on to the head office work, the important return in connection with bad and doubtful debts calls for remark. This return is made up at each branch and despatched to the chief office some little time (say, one month) before the actual balance. In it all past due bills are fully detailed, the security held and prospects of payment being dealt with at length, and the probable loss (if any) stated. Any loans or overdrafts considered in any way doubtful are dealt with in a similar manner, although the return may include every loan, whether doubtful or not. In addition, if any loss is thought likely to result on any bills held but not matured, the circumstances will be recorded in this return, which, on being received at the head office, is carefully gone into by some of the principal officers, and the amounts required to be set aside against probable losses determined.

Head Office Balance Work. The ordinary weekly audit is pushed forward as quickly as possible, and after it is finished the outstanding entries in the bank's account are dealt with, a special cross entry book or journal being utilised. The first class of such entries deals with the transfer of the balances of the profit and loss accounts at the branches, made by these offices on the last day of the half-year. These are carried to the profit and loss account. The book to which the outstanding drafts and transfers are weekly transferred is next taken in hand, and the items of this nature remaining unpaid agreed, these will be probably detailed in the book itself, the total being entered in the special journal, and appearing in the balance-sheet as a liability. Special entries carry the bills discounted and debited to the receiving branch on the last day of the half-year to a special account, the total of which is included in the amount shown against bills in the balance-sheet. A similar procedure is adopted with cheques and with any other entries unresponded to.

The amount of cheques in transit may either be included in the amount of ledger loans or combined with the cash items. The entries in this special journal, or cross entry book, clear out all sums outstanding in the weekly returns, anticipating the responding entries appearing in the returns subsequently received. In the case of a bank possessing only one office, these entries will be unnecessaiy ; but entries for unapplied interest, etc, require to be passed in every case.

The amount due by the bank as interest accrued but not paid, rebate, etc., forms a charge on profit and loss, while interest, etc., earned during the period just closed, but which has not been applied, requires to be credited as profit. Entries, based on the branch returns, will accordingly be passed.

Debiting Profit and Loss and	Crediting Suspense with	Interest due at date of balance by the bank on deposit accounts and deposit receipts, rebate on bills discounted.
Suspense	Profit and Loss	Interest due at the same date to the bank on loans, overdrafts, investments, rent.

As suspense account acts as a transfer account between the profits of one year and another, before any entries are made relating to the current balance the sum resulting from those passed at the preceding one is removed from suspense and carried to profit and loss. An amount of interest due to the bank, outstanding on the 30th June (the date of the balance) and paid the following day, will, if the next balance is on the 30th December, be included in the amounts of entries passed, as follows :

	Debited to	Credited to
June 30..	Suspense	Profit and Loss
July 1..	Current Accounts	Interest
Dec. 30..	Interest	Profit and Loss
	Profit and Loss	Suspense

The amount of suspense account will be included in the balance-sheet in the total of either current account deposits or loans.

Continued

FLOORS AND PARTITIONS

The Three Classes of Floors—Single, Double, and Framed. Floor Joists. Ceiling Joists. Trimming. Strutting. Binders. Girders. Various Forms of Partitions

CARPENTRY
continued from
page 4254

By WILLIAM J. HORNER

A FLOOR consists of a framework of joists covered usually by flooring boards, the work of laying down the latter being allotted to the joiner. Floors are no longer invariably constructed of wood alone. In floors of large area, steel girders are employed, and in warehouses, factories, and other large buildings even flooring boards are sometimes discarded in favour of concrete or other material. In such cases there is no carpentry work.

There are three types of framework on which flooring boards are laid, the span of the floor usually deciding which must be employed. In all cases the boards rest on a series of joists about 12 in. apart, running in the transverse direction to the boards. In the simplest type of floor, called a *single floor*, these joists bridging from wall to wall [**284**] are all that is necessary. In spans which exceed 20 ft., and often in much smaller ones, the joists themselves are supported at one or more intermediate points by a larger transverse timber called a *binder* [**285**]. This intermediate support makes it possible to use flooring joists of smaller dimensions than would otherwise be necessary. It is then called a *double floor*. In floors of very large area, further transverse members, known as *girders* [**286**], are employed to afford support to the binders. Such a floor is a *framed floor*. It is called framed because the girders and binders are generally framed together at the points where they cross, but in some cases, where the increased depth of the framework of the floor is not objectionable, the binders rest on top of the girders.

Single Floors. In single floors, where joists alone are used, they are usually made to bridge the narrowest way of the room or building. Their ends rest on wall plates, or templets, which in upper floors are usually built into the wall, and in ground floors are set on brick offsets. Very often offsets can be arranged for the joists of upper floors by reducing the walls in thickness above each floor. When built in, the templets are of stone or metal, in preference to wood, because the latter decays in such situations and is bad in case of fire. At least ¾ in. of air space is allowed round the ends of joists to prevent decay. Joists which do not have to span more than from about 8 ft. to 12 ft., should measure in section about 2 in. by 8 in., which is the average dimension, though 2 in. thick is a minimum, because a continuous line of nails has to be driven into them to hold the flooring boards, and less than 2 in. would be likely to split. Floor joists, like the common rafters of roofs, do not need to vary in strength with the area of surface covered, because it is found best to support them at intervals of about 8 ft. Long timbers are generally slightly curved in length, and should always be laid the rounding side up, to allow for sagging. Knots, if possible, should always be at the top, because they stand compression better than tension, and therefore are in the best place when in the upper portion of a beam.

In ordinary dwelling houses, single floors are usually sufficient as far as strength is concerned, but what is rigid enough for a floor is often not sufficiently so to prevent a ceiling below from cracking if the laths and plaster are attached directly to the under surfaces of the floor joists. Another objection to a single floor is that it transmits sound from one room to the other very readily.

Ceiling Joists. Without introducing binders to support the joists, these two defects may be reduced by attaching ceiling joists to the under surfaces of the floor joists [**288**], contact between them being made only at every fifth or sixth joist, to lessen the surface through which sound can pass. This is sometimes called a *double floor*, though it differs from the double floor in which binders are used. As ceiling joists have only the laths and plaster of the ceiling to support, they are of small dimensions compared with floor joists, being frequently not more than 1½ in. by 3 in., or 2 in. by 3 in. In floors where they have to span 8 ft. or 10 ft. from binder to binder, they may be 2 in. by 5 in. In single floors ceiling joists are nailed, and usually notched as well, to the under surface of the joists, running, of course, transversely to the latter. In double floors they are generally fitted between the binders [**291**] to avoid adding needless depth to the floor. In all cases they project slightly below the other members of the floor framework, so that when the laths are nailed to them there will be no other surfaces to prevent the plaster passing through and becoming keyed to the laths. When ceiling or floor joists are more than 2 in. thick, strips 1 in. square are often nailed to their under surface, to attach the laths to, thus affording a better key for the plaster.

Trimming. Examples of trimming are shown in **284**. Trimming is necessary in almost all floors, in order to keep the joists clear of fireplaces, stairways, and flues in walls. The trimming pieces which enclose the open space are stouter in section than the ordinary joists, an increase of an ⅛ in. generally being added to their width for every joist supported by them. The joints are usually tusk tenons, because that affords the best support with the minimum weakening of the timbers. Sometimes stirrups are used instead. When the trimming can be effected in line with the joists, as at A [**284**], it is,

of course, more satisfactory, and when the position of a fireplace or stairway is fixed this sometimes makes it advisable to run the joists the longest instead of the shortest way of the span, in order to simplify the trimming. On ground floors no trimming is required, because brickwork can be built out to support joists where necessary. The trimmed space before fireplaces is made flush with the floor boards by a hearthstone, the edges of which rest on the wood trimming and the body on a bed of concrete, which is laid on an arch within the trimmed space. This arch is sometimes of wood, but more often of brick, as in 290. Sometimes a flanged sheet of steel is employed. When the arch is large, its pressure against the wood trimming is considerable, and the latter is often better enabled to resist it by the insertion of long bolts, the nut ends of which go through the wood, while the other ends are hooked and built into the wall.

Strutting. Struts, or braces, between joists [289] enable them to assist each other in supporting a load and prevent them from twisting. They are placed in continuous lines at intervals of about 4 ft. In a span of 8 ft., for instance, there would be one line of struts across the centre. The herringbone method of strutting is the best and most commonly employed. The struts are in section about 2 in. sq., with their ends cut to the correct angle. They are held by a nail at each end, driven generally through a saw cut instead of a bored hole, as the former is more easily made, and obviates the risk of splitting. Solid struts are also sometimes employed. They are made slightly less in depth than the joists, and the whole series are sometimes tightened by a long bolt passing through the joists close to the strutting.

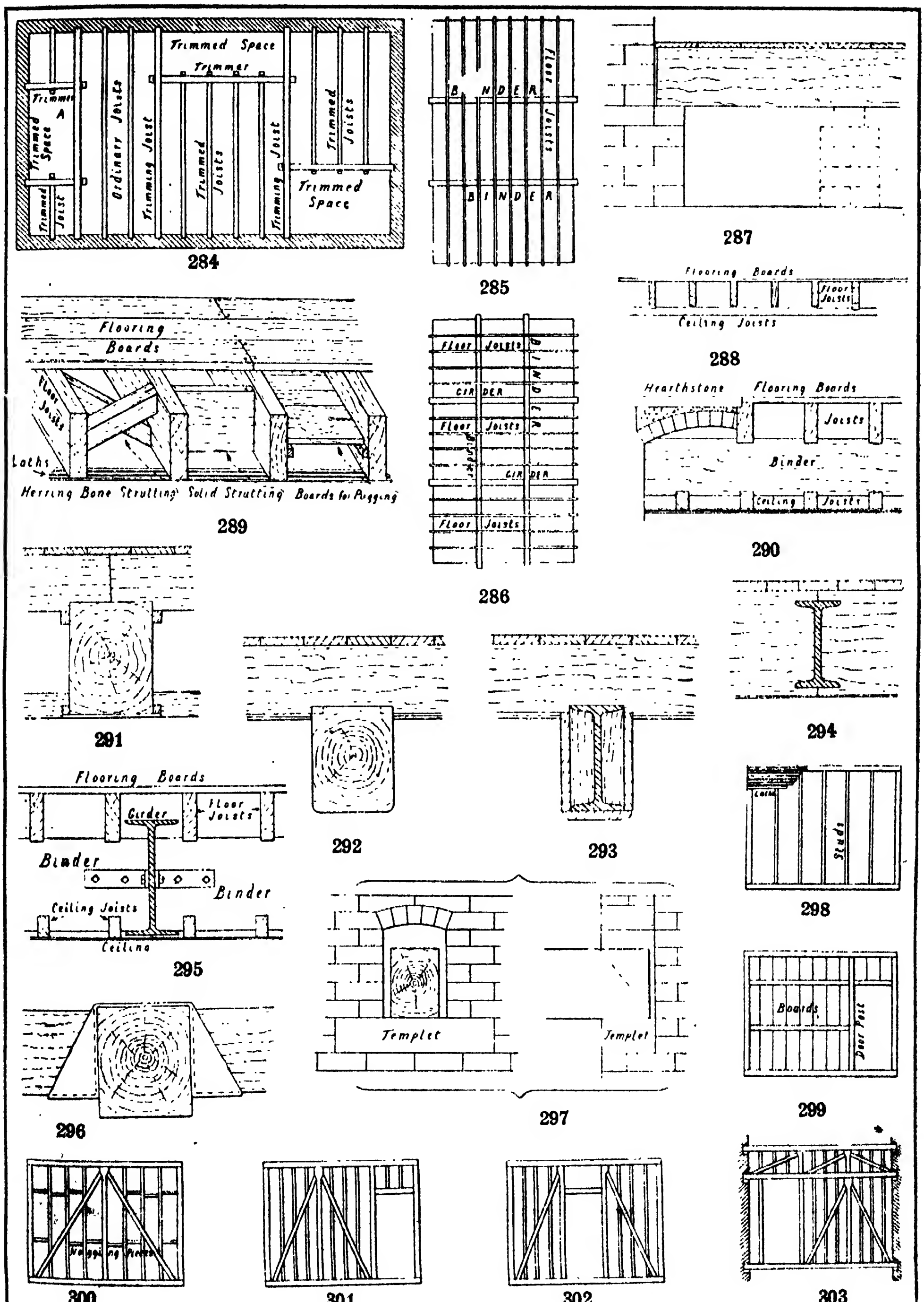
Pugging. This is often resorted to for preventing, as far as possible, the passage of sound and odour through a floor. The carpenter nails fillets and lays boards on them, as in 289, and on this is deposited rubble or other suitable material for absorbing sound. Another method is to tack felt on the tops of the joists. Sometimes felt is put on in continuous sheets dipping down between the joists so that it will support sawdust or other material in the same way as the boarding shown in 289. An objection to pugging is that the absence of ventilation tends to induce dry rot in the wood.

Double Floors. A double floor is made up of binders, floor joists, and, in most cases, ceiling joists. In these floors the binders usually lie the shortest way of the span, and they must rest on substantial parts of the building, never where there are window or door openings below. This, of course, is still more important in the girders of framed floors. Fig. 285 shows a double floor in which two binders are used, thus dividing the entire joist length into three spans. In many cases only one binder is necessary to support the middle of the joists. The floor joists are either cogged on top of the binders [292] or notched, and perhaps also supported on fillets, as in 291. The ceiling joists below are notched on, or fitted between, sometimes tenoned in with chase mortises, but a better method is that shown in 291, in which they are supported on fillets. Binders are very often of steel instead of wood. Sometimes they extend below the ceiling level, as in 292 and 293, and have their corners rounded or beaded if of wood, or are boxed in if of steel. The distance apart of binders may vary greatly according to circumstances, but an average distance is about 6 ft. or 8 ft. Sometimes, to avoid building all the joist ends into the wall, binders are used to support the ends of the joists, leaving a little clearance between wall and joist ends. Occasionally, when steel binders are employed and it is desired to keep the floor depth as shallow as possible, the joists may be framed between the binders as in 294, or in any other convenient manner, but, as a rule, joists rest on top of binders.

Framed Floors. The girders of framed floors [286] are now almost invariably of steel. When of timber they are generally flitched by bolting two halves together, with an iron plate between. In a few cases the binders rest on top of the girders, but, as a rule, they are framed together to avoid great depth of floor. When there is no ceiling the girders are sometimes placed below, or, even with a ceiling, they can be treated in the same way as the binder in 293. When framed together in the same plane the lower flange of the metal girder is utilised to support the binder ends [295], and further security is obtained by bolting brackets or angle irons to the sides. Either wood or metal members may be connected in this way. When the girder is of wood tusk tenon joints may be made, but they weaken the girder by the removal of some of its substance, and therefore it is more satisfactory to support the binder ends by light iron stirrups [296]. Generally, the distance between girders should not exceed 10 ft., but this depends on circumstances. Binders are never allowed to occur near the middle of girders, but are always divided equally on each side to strain them as little as possible.

The ends both of girders and binders rest in pockets in the walls [297], or on built up offsets; occasionally on projecting corbels, but this is not so satisfactory as either of the preceding. They are also often carried in cast-iron shoes or stirrups built into the wall. If the latter plan be substantially carried out, and the timbers be not heavy, it is better not to let them enter the wall at all but merely to rest in the stirrup, because in case of fire they cannot then damage the wall when they break and the ends tilt up. Another good means of accomplishing the same end is to bevel the ends of the timbers as indicated by a dotted line in 297. This does not appreciably diminish their strength, allows them to enter the wall, and also leaves plenty of air space. The main timbers in ground floors may be supported intermediately by brickwork [287], and those in upper floors by pillars or stanchions.

Flooring Boards. These are generally laid down by the joiner. The forms of edge joints between boards have already been shown in 132 to 139 [page 3845], but plain square butt joints are



TIMBER IN FLOORS AND PARTITIONS

284. Single floor **285.** Double floor with two binders **286.** Framed floor **287.** Brickwork for main timbers **288.** Ceiling joists **289.** Strutting and pugging **290.** Floor with brick arch for hearthstone **291.** Double floor **292.** Cogged floor joist **293.** Steel binder in floor **294.** Joists framed between binders **295.** Floor showing girder and binders **296.** Binder supported by iron stirrups **297.** Wall pockets for girders and binders **298.** Simple partition **299.** Partition with boards instead of laths **300-303.** Trussed partitions

frequently employed for flooring boards. They are generally nailed on to the joists with flooring brads. In some forms of joints these can be concealed. Occasionally, in high-class work screws are used, their heads being sunk about ½ in. and the holes afterwards plugged with wood, the grain of which runs the same way as the boards. End grain joints may be either square or splayed. In the latter case only the overlapping part need be nailed. These joints must, of course, always occur on joists. For the sake of uniformity the lengths are usually arranged so that alternate boards are joined on the same joist. An unbroken line of heading joints is never allowed to occur on one joist as it would be a needlessly weak arrangement. To minimise the opening of joints through shrinkage of boards in their width, they should be well seasoned and tightly cramped together in laying. Narrow boards shrink less than wide ones. In good floors two thicknesses of boards are sometimes laid, one at right angles to the other. In such cases the upper series of boards are usually of hard wood and less in thickness than the lower ones. Wood blocks are sometimes employed instead of boards, but they are laid on concrete.

The laying of floor boards should be delayed as long as possible to avoid getting them swollen by dampness in the building, and subsequently shrinking badly. When put down they should be as dry as possible. In cases where two layers of boards are put down transversely to each other, the under ones may be laid as soon as the joists are ready for them, and the others put on when the main work of the building is completed.

The Carpenter's Work. The dimensions of the timbers are decided by the span and by the weight the floor has to carry. This latter ranges from about 1¼ cwt. allowed for each square foot of floor surface in dwelling-houses to 3 cwt. in warehouses and factories. The stability of girders and binders, and the supports on which they rest, are of more importance than joists, which need not vary greatly in section in any floor. The carpenter is provided with timbers of the section required, and his work consists in cutting them to length, making the necessary joints, and securing them in place. This is generally done while the walls are in course of erection, because it ties the walls and also provides staging on which planks can be laid temporarily for convenience in building. As, with the exception of flooring boards, the wood is all concealed when the building is finished none of it is planed, and no regard need be paid to appearance. The work is usually of a simple character when the arrangement of timbers has been decided on, for the joints, both at ends and at intersections, are repeated, and are plain in character, with the exception of tusk tenons, which are now comparatively seldom employed.

Partitions. Partitions between rooms are very frequently of wood instead of brick or stone. The simplest form of partition is shown in **298**. It is called a *studded* partition, and is intended to rest on a floor or joist. It consists of a square frame, the outside members of which may measure 3 in. by 4½ in. or 4½ in. by 4½ in. in section, filled in with a series of studs measuring 2 in. by 4½ in. placed at intervals of 1 ft. or 2 ft. Laths are nailed across these and plaster laid on as for a ceiling. Another method is to use boards in place of the laths [**299**], two horizontal rails being shown in this case, the upper one corresponding with the top of the doorway. Sometimes the spaces between the studs are filled in with brickwork, and these are called *bricknogged* partitions. The partition is usually 4½ in. thick, to correspond with the bricks, but in some cases when the partition is very small, it is made 3 in. thick, and bricks may then be built in on edge. In many cases the weight of the partition cannot be allowed to rest on a floor, but must be carried directly by the walls.

Trussed Partitions. The framework then has to be trussed in a very similar fashion to that of roofs. Figs. **300** to **303** are examples of partitions which are said to be trussed, and which will bridge from wall to wall, with much more rigidity than the first two examples. Doorways at the side are usually necessary, and this complicates the trussing. Trussing, however, is not often now carried out so elaborately as formerly, the walls being often bridged by a steel girder which supports the partition, or the partition is arranged to come over one of the floor girders or binders, the dimensions of the latter being increased, if necessary, to carry the extra weight.

The vertical studs are often stiffened by transverse nogging pieces. These may be fitted between [**300**], generally out of line as shown, for convenience in nailing them in; or they may be in one piece notched in, either flush or slightly below the surface of the studs. In some cases short pieces are rebated between, instead of simply nailed. When laths and plaster have to be attached, the studs are generally a trifle wider than other parts of the framework of the partition, so that the latter will not interfere with the key of the plaster. As with ceilings, narrow strips are sometimes put on the surface of wider pieces so that when the laths are on the plaster will not have its hold interfered with by the wide surfaces immediately under the laths. The attachment of narrow strips for this purpose, both in ceilings and partitions, is called *brandering*, or *firring*. Studs are stub-tenoned, and principals tenoned through at top and bottom.

In large trussed partitions the joints and methods of connection very much resemble those of king and queen post roof trusses. Straps and bolts are used in the same way, and the methods of jointing are the same. The horizontal member at the base is called the *sill*, the one at the top the *head*, and intermediate ones *intertie*. The vertical members at the ends are *wall posts*, and those which form doors are *door posts*.

Continued

SOUL AND MATTER

The Physics of the Body. Animal Magnetism. Mesmerism and Hypnotism. Psychical Mysteries Can Never be Explained by Physics

Group 24
PHYSICS
31

Continued from page 4246

By Dr. C. W. SALEEBY

IT is good to have the opportunity of discussing, however briefly, a subject of very grave interest, which has unfortunately lent itself to all sorts of quackeries and abuses. It has long been positively known that the living body possesses a number of remarkable electrical properties. We have already seen, for instance, that electrical changes are produced in the retina of the eye by the influence of light. Muscular tissue, also, is the site, under certain conditions, of the production of an electric current. We may briefly remind ourselves of the celebrated observation made by Galvani, in 1786, of the motion in a frog's limbs hung from a metal railing. We now know that the muscles of that limb were alive. No current can be produced in dead muscle. The brief facts we have noted are only indications of the existence of a very interesting branch of science known as *animal electricity*.

Mesmer and Mesmerism. But the term *animal magnetism* has been applied to phenomena of a different kind. They were first and most notably exploited by the celebrated Anton Mesmer (1733–1815). It was his theory that the influence exerted by certain persons upon other persons, and notably upon some of their diseases, is really of magnetic origin. It was a reasonable inference from this theory of animal magnetism that similarly satisfactory results might be obtained from the use of ordinary magnets in the treatment of disease. It was not long, however, before Mesmer discovered that this theory did not hold; nevertheless the term animal magnetism survives to this day, and is still used or abused in many quarters. Only last year (1905), for instance, there was published, under the title "Personal Magnetism, Telepathy, and Hypnotism," a book which contains a good deal of truth, but which, unfortunately, tends to perpetuate a delusion. We may say positively that, in the sense in which the phrase has been used since it was first coined, there is no such thing as animal magnetism.

We must not be misunderstood. It is one thing to assert that there is no such thing as animal magnetism, another and an entirely different thing to deny the reality of the remarkable and extremely important phenomena which this stupid phrase has been called upon to explain. Mesmer was a clever man, but he had much quackery in him, and his successor, the Baron Reichenbach, was like unto him. This man believed that he had discovered an *imponderable*, or, as we should now say, a new form of energy, which he called *odyl*, produced by magnets, the human body, and other means.

Hypnotism. It was just about this time that, in 1841, James Braid, a Manchester surgeon, dismissed the physical explanation from the realm of the credible and raised the whole subject to a new plane. We owe to him the now recognised word *hypnotism*. The terms mesmerism and animal magnetism should be entirely dropped. They are wholly misleading, and indicate no truth at all. Amazing as the facts of hypnotism and suggestion are, and of the profoundest interest for the student of the mind, they have nothing whatever to do with what physicists have called magnetism, and the sooner the fact is generally recognised the better.

It has been thought by some that the recent and extraordinary extension in physical and chemical knowledge would reveal some basis of fact for the theories of those curious people who persist in desiring a materialistic explanation for these phenomena. This is not so, however. Neither the "chemistry of the ion" nor the "chemisty of the electron"—to quote useful phrases employed by Sir. Wm. Ramsay—has given the smallest indication of any physical basis for the facts of hypnotic suggestion; nor need the N-rays be adduced as providing a probable explanation. Whether these N-rays exist or not, at any rate they have nothing to do with hypnotism, which is concerned with the action of *mind upon mind*, and with that alone.

Human Radio-activity. The question arises, however, whether there has not been demonstrated such a thing as human radio-activity, and whether *this* does not furnish at last a reasonable physical explanation of the facts of suggestion or animal magnetism so-called - the term radio-activity merely being substituted for magnetism in the light of more advanced physical knowledge. In studying this question, the first point to consider is the existence of human radio-activity. As we have already seen, it is probable that radio-activity is a property possessed in varying degrees by all forms of matter, that which composes the living body being no exception. But, as we have also seen, there is only a very scanty group of rare elements which display radio-activity in anything like a high degree; indeed, the possession of this property by any elements other than radium, uranium, thorium, and a few more, is a matter of speculation and inference rather than actual demonstration. Now, though traces of these elements are possibly to be found everywhere, they are certainly not amongst the recognised constituents of the human body. For practical purposes, we may say that human radio-activity is a myth. If the living animal body displays any radio-activity at all, it is entirely negligible, being certainly

no greater than that of a host of impotent substances which have never been credited with the possession of "magnetism." That explanation must therefore be dismissed.

The Body is not Radio-active. The notion that the living human body is radio-active is due to a popular error as to the meaning of the term *radio active*. Readers of this and its companion course are aware that radio-activity is the outward and visible sign of an inward atomic evolution, and that this sign consists of the expulsion of electrons or charged units of negative electricity from the radio-active atom. It has been thought, however, and some of the medical papers have helped to propagate the error, that the term radio-activity means simply the production of rays. If this were so, the term would have no special meaning at all. Everything that transmitted light rays or heat rays would be radio-active in that sense. But the rays produced by radio-active bodies are not ethereal waves at all, but are actual particles or corpuscles.

The human body certainly does transmit ethereal waves, though there is no reason to suppose that these differ in quality or quantity in different persons according as whether they possess a high or low degree of *personal magnetism* so-called. The body reflects light that falls upon it. It also emits in large degree the waves of radiant heat. If we are to believe Professor Blondlot, the body also produces the particular kind of ethereal waves that are named after him, and if we are to believe his colleague, Professor Charpentier, these are produced in exceptional degree by active nervous tissue. None of these properties, however, has anything to do with radio-activity.

Non-physical Explanation of Psychical Things. Furthermore, all these properties may be absolutely excluded from the causation of the facts of suggestion. We may study the physics of the body as closely as we please, but we find nothing whatever that affords a physical or materialistic explanation of these facts. On the contrary, we are confirmed more than ever in our knowledge that they have nothing whatever to do with anything physical or material. They belong to a totally different order of existence, and no matter how subtle or refined or impalpable our conceptions of physical existence may become, we are not one whit nearer finding the psychical in the physical. The difference between the two is the most ultimate, fundamental and absolute of all differences in the universe; all other differences are superficial. Any kind of matter or energy can be transformed, we may believe, into any other kind, but soul can never be expressed in terms of matter.

The term *personal magnetism* is only one more illustration of the constant attempt to explain the psychical in terms of the physical. If the reader desires to realise how constant this attempt is, let him study the materialism which has always been, and still is, the curse of religion, and from which only the religious conceptions of the few in any age are free; then let him turn to language and, as in the case of the two meanings of the word *spirit*, he will realise that men have always tried to express the psychical in terms of the *rarefied physical*.

The Materialism of Human Thinking. Thus, in discussing the phenomena of suggestion and hypnotism, we must be entirely independent of any physical terms. We have to employ such words as suggestion and subconsciousness, but we will surely err whenever we introduce material language. The explanation of the whole illusion is immensely significant; it is to be found in the incurable materialism of nearly all human thinking. A purely psychical explanation will never satisfy anyone but the philosopher. The common people want something material, but, of course, they want it rarefied. They will be most indignant if it is suggested that the soul consists of matter—and rightly so. But if we suggest that the basis of the soul is electrical or ethereal, they are impressed, not realising that this explanation is just as materialistic as the other, and equally worthless. Thus, even at the present day, when some people who sternly reprobate materialism find solace in ridiculously materialistic explanations of psychical phenomena, we see the persistence of that habit of mind which the study of religions and the study of language which is almost incurably materialistic—proves to have prevailed amongst mankind throughout the whole of history.

Thirty years ago it was thought by some that physics, or, rather, the group of sciences which we include under that term, was approaching something like finality. There was doubtless much room for improvement in detail, but the great discoveries had been made. The last decade, however, has witnessed what is nothing less than a transformation of many aspects of physics and the addition to it of new sciences. Radio-activity is by no means the only subject which has sprung into new existence of late years. We must attempt to outline the main facts of some of these in the brief remainder of our course.

The Higher Psychics. It is to be hoped that we shall recognise how the "Great Mother of the Sciences," in giving birth to all these young children, has not lost her maternal control over them. On the contrary, every day shows more clearly, first, that each development in physics may be trusted to throw light upon subjects which, at first, may seem scarcely cognate, and, in the second place, that the empire of physics is steadily widening. Already we are on the verge of explaining all chemistry in physical language, as being none other than a matter of applied electricity, and the time is at hand when the whole of astronomy will be similarly included within the grasp of the great principles of physics. We cannot yet say that biology itself must be regarded as demonstrably no more than a higher physics, but the more closely we study living things and living matter, looking at them dynamically as well as statically, the more certain are we that this statement will one day be regarded as a platitude.

Continued

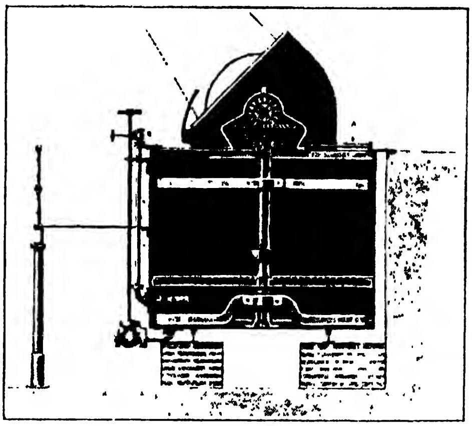
RĚFINING SUGAR

Melting, Filtering, Decolorising, and Boiling Down Processes. Crystallisation. Loaf, Cube and Granulated Sugar. Treacle. Golden Syrup. The Refinery

continued from page 4301

THE term *refined sugar* is used for those finer qualities which are made from raw sugar at central refineries, and in which animal charcoal has been used for decolorising. The term is often incorrectly applied to chemically treated beet sugars. Sugar refining is mainly a mechanical process, and consists briefly in dissolving the sugar in water, filtering through cloth to take out suspended matter, and then through animal charcoal to remove colour. The clear bright liquid is finally evaporated and boiled to crystallisation.

Preliminary Treatment. The raw sugar is usually submitted to a preliminary treatment before the first stage. The raw sugar is mixed with a small quantity of syrup, put into a centrifugal apparatus, and washed with steam until the syrup flowing from the centrifuge comes away of a light colour. Raw sugar may be said to consist of sugar crystals and molasses, and by washing out the latter the purity of the sugar is at once raised by this treatment. The method was first suggested by Weinrich, but much improved subsequently by Duncan and Newlands chiefly in the method of admitting steam and separating the grades of syrup. The process separates the raw sugar into partly refined crystals and washings containing a good proportion of the molasses.



21. MELTING OR BLOW-UP PAN
a. Charging opening *b*. Steam valve *c*. Steam injector for heating *d*. Discharge valve

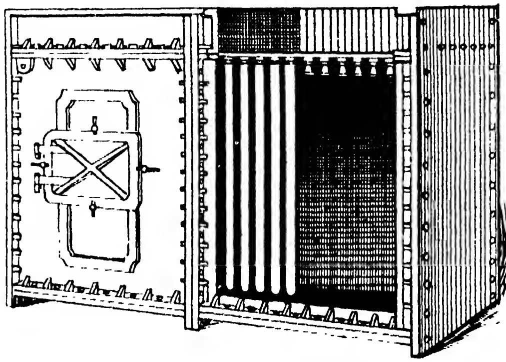
Melting. The partly refined sugar is dissolved in water, or as it is termed *melted*, the melting-pans, holding 3 tons to 10 tons, being known as *blow-ups*. The sugar is passed through a grating into the blow-up, which is provided with a false bottom, stirring gear, and heating arrangement either of copper coils or for live steam [21]. Here the sugar is melted at a temperature of 150° F. to 170° F. to a syrup of 28° Beaume, and is then filtered. In the case of low quality sugars defecants are used in the blow-ups, the oldest and best known being blood.

Filtration. Most refineries in Great Britain use the old Taylor bag or stocking filter [22] for clearing the liquor produced above, although the Danek filter is the favourite on the Continent. The filter presses described under Beet Sugar Manufacture are also used, but not to any great extent [page 4163]. The Taylor filter consists of a large iron chamber with tightly-fitting doors in the front. At the top is the tank or filter head, leading to a series of metal sockets to which long filter bags are attached. These bags are made of twilled cotton measuring 6 ft. long and 2 ft. to 3 ft. wide when opened out. The bags are put into sheaths of coarser material, and, the sheaths being smaller than the bags, a larger filtering surface is ensured. The bags are securely fastened on to the nozzles, and hang inside the chamber, which is fitted with steam heating appliances. A filter chamber contains 200 to 500 of the filter bags, and each bag can be separately controlled by plugging the hole leading to it from the filter head, this being necessary when one of the bags turns out to be defective. Some modern forms of Taylor filters have removable filter heads, so that the whole battery of filter bags can be removed at once and replaced by a fresh set.

The liquor from the blow-ups is run on to the filter head, and passes into the bags, the temperature being maintained by letting steam into the filter chamber. When the bags become blocked up with dirt the liquid ceases to pass, the supply of liquid is cut off, and the bags allowed to drain. The bags are then detached, and washed systematically in several tanks of warm water, the washings being reserved on account of the sugar they contain and run into the *sweet-water* tank.

Decoloration. From the Taylor filter the bright liquid is passed to large char cisterns. These are iron towers from 18 ft. to 50 ft. high, filled with animal charcoal or char. The bottom of the char cistern is a perforated plate covered with a blanket, and on this the char is packed to within a short distance of the top. The bright liquor, still warm, is allowed to flow in at the top, and, when full of liquid, the bottom cock is turned off and the whole left to "settle" for some hours. A char filter holding 20 tons of char has room, in addition, for about 10 tons of liquor. After a few hours, the cock at the bottom is opened, and the liquor, now free from colour, drains away. More liquor is slowly introduced, until the filtrate becomes tinted, when the stream of liquid is passed into a separate vessel for a lower grade product. This is continued until the colour shows that the char has ceased

to work, when the supply of liquor at the top is cut off, and what remains in the char cistern drained off; the char is then washed with hot water, and the washings run into the sweet-water tank as long as they show the presence of notable quantities of sugar. The char is in this way washed till the water runs clear, when it is allowed to drain, and the char taken out and revivified by burning. In some sugar houses, sulphurous acid is added to the yellow liquor and exerts a very effectual bleaching action, any excess of acid being expelled in the subsequent heating operations. Char-washing machines much used.



22. TAYLOR FILTER

Reburning Char. The revivification of the charcoal is effected in pipe kilns [23]. The pipe kiln consists of a series of cast-iron pipes into which the char is placed and heat applied to the outside of the pipes. The kilns are heated either by direct coke firing or by gas, the advantages of the latter method being that there is an economy of fuel, absence of ashes, and greater uniformity in heating. Beneath the kiln pipes are corresponding cooling pipes. The char is brought to the kilns wet, and is first dried and then, having been filled into the kiln pipes, is heated red hot. The char is next passed to the cooling pipes beneath by means of discharge valves, the contents of the cooling pipes being passed to a hopper, and from this taken to the char cistern for use again.

Animal Charcoal. Animal charcoal is prepared from bones by first degreasing them by heating with water or a solvent such as benzene, and then carbonising the bones in retorts. The carbonising takes six to eight hours and during the process bone oil and ammonia are given off and collected separately. The charred bones are then placed in air-tight bins to cool, and, after cooling, crushed and graded by sifting. Sugar refiners prefer a fine grain char for decolorising purposes. Why charcoal decolorises is not easily answered, but organic bodies in the char play an important part as colour absorbers. These organic bodies are gradually dissolved out by the sugar liquors, and although the char can be revivified a large number of times there comes a time when the organic bodies referred to are used up and the charcoal is useless.

23. CHAR REVIVIFYING KILN
(J. Buchanan & Son, Liverpool)

Alternative processes of revivification have been suggested by artificial cultures of bacteria.

Many substitutes for char have been proposed, several of them containing carbonaceous matter with absorbent earths. They fall far short of char.

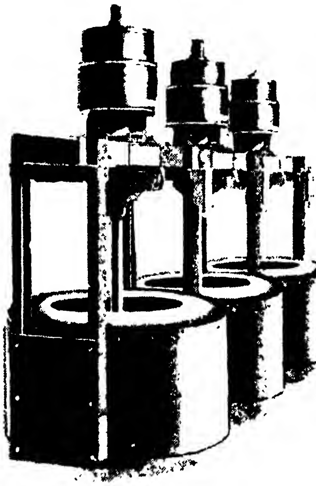
Boiling down is effected in the multiple effect apparatus and vacuum pans described in the article on beetroot sugar manufacture.

Crystallisation in Motion. In 1891 the Machinenfabrik Grevenbroich patented their method of crystallising in motion—a distinct advance on previous practice. The massecuite from the pan is run into the apparatus, which takes the form of a large cylinder, and is kept in very slow movement by a stirring arrangement. In most cases hot water is circulated in the outer vessel to control the cooling, and in some cases the vessel is airtight and worked under a partial vacuum, air pressure being utilised to empty the pan when finished. The process prevents the formation of small grain by inducing the crystallisable parts of the massecuite to grow on crystals already formed or introduced. In the latter case the crystals are brought up to the temperature of the massecuite before being added. The advantage of having large crystals over small ones is that the separation of molasses in the centrifugal machines is much facilitated.

The method is used in beet sugar manufacture as well as for residual products of the refinery.

Centrifugal Machines. When sugar is to be *machined* it is run from the vacuum pan into a heater fitted with stirring gear. From this it is placed into the baskets of centrifugal machines which, when revolved at a high speed, throw out the syrup. The sugar is more or less washed, discharged into bins, air dried, and packed in bags holding 2 cwt. for sale. The syrups and washings are collected separately; from the syrups another crop of crystals is obtained, while the washings, being

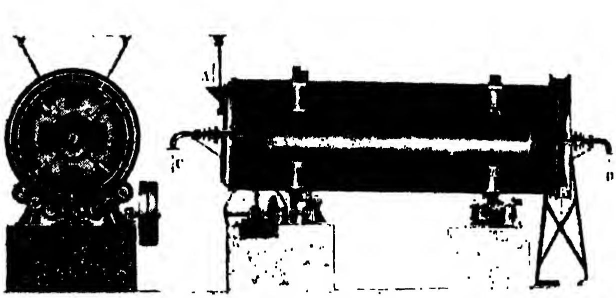
purer, are boiled up with the liquors used for producing first product sugar. The centrifugal machine [24] is an apparatus which by water, belt, or electrical driving is spun at a rate varying from 500 to 1,200 revolutions a minute. It is arranged for discharging the contents at the top or bottom and has washing or steaming appliances. Superheated steam is used in the Baker process. The basket into which the sugar is placed is made of perforated metal, the revolution of the basket causing the mass of crystals and molasses to be violently thrown against the inner wall; the molasses and a portion of the crystals pass through the perforations, but the greater part of the crystals are retained in the basket. Centrifugals are either driven or suspended, the latter type being used more. The size of the basket is 30 in. diameter, but a larger size of 48 in. diameter is in use which, although economising labour, takes more power to drive.



24. CENTRIFUGAL MACHINES (Watson, Laidlaw & Co., Glasgow)

Loaf Sugar. The oldest form of refined sugar is the sugar loaf. To make these the massecuite is formed with a small grain, run into a heater and raised to between 180° and 190° F. From this the mass is run into conical iron moulds, which have a small hole at the top or cone and a series of moulds is placed cone downwards in a supporting frame. The hole at the bottom is stopped up with a wooden spike. When the sugar has partly solidified the contents of the mould are mixed up with a "brushing off" hook with the object of making the texture throughout the loaf even. The moulds remain in the filling-house for 10 or 12 hours and by that time the contents have become solid. Next, the moulds are removed to a warm room, the plugs in the cones removed and "green" syrup drips from the mould for about 24 hours. A process known as liquoring then takes place. The top surface of the sugar is removed, mixed with syrup (*white liquor*, *cleare*, or *clairce*), and replaced. White liquor is then fed on to the top of the loaf and drains from the cone, taking with it any coloured impurities that remain in the sugar. The liquoring is repeated several times, blued water being used for the final liquoring until the runnings are quite clear and the loaves of uniform whiteness. Special appliances are in use for supplying measured quantities of clairce to the cones, and suction apparatus worked by compressed air is employed (by Steffen & Scheibler) to hasten the passage of the liquor through the sugar loaf. The loaves are eventually taken out of the moulds, dried in racks, and wrapped up in thick paper. The process takes about a fortnight. The blued water referred to above is prepared from pure ultramarine, the purpose of the slight addition of blue being to correct any remaining tint of yellow. Special centrifugal machines are made for purging sugar loaves in the centrifuge, and many machines have been devised for finishing off the loaves and also for cutting them into cubes.

Cube Sugar. The slowness of the method of making sugar loaves has led inventors to study the question of how to make cube sugar in a quicker manner. Many inventions to this end, which involve similar principles, have been patented. The massecuite is boiled to small grain and filled into divided moulds of such a size that a plate of sugar is produced. The moulds are either a kind of centrifugal basket or contrived to fit into the centrifugal basket. The massecuite is cooled in the mould, during which process the crystals are joined together by a secondary crystallisation. The cooled moulds are then put in the centrifugal and the syrup spun out. The plates are also washed with clairce, which is in turn spun out. The moulds are removed and taken apart, the plates of sugar being separated and dried in a special store in a current of hot air. When the plates of sugar are dry, they are cut up into cubes in machines invented for the purpose. The Adant cube sugar process is worked on the above lines.



25. GRANULATOR
a. Charging hopper *b.* Discharge valve *c.* Steam inlet pipe *d.* Water outlet pipe

Cube Sugar is Ousting Loaf Sugar. Another principle adopted in some machines, such as the Hersey cube machine, is to produce sticks or cubes of sugar by means of pressure

from soft, white sugar that has been dried and purged in the centrifuge. This process is much used in the United States. The method outlined above, in which the cubes are made from the massecuite direct, is preferable. The cube form is fast replacing the old form of loaf sugar.

Granulated Sugar. Granulated sugar is produced by the Hersey process, patented in 1873. The granulator [25] consists of an outer conveyer cylinder 23 ft. long, 6 ft. diameter, inside which is a smaller cylinder 23 ft. long, and 30 in. diameter, arranged to revolve about five times in a minute, and heated internally by steam. The granulator is inclined from the horizontal position, so that sugar introduced at one end travels mechanically to the lower end. A current of air is passed or driven through the drying chambers to absorb the moisture that arises from the sugar during its passage through the granulator. Sugar is first washed in a centrifuge, and then passed through the granulator, about 30 barrels of sugar being treated in an hour.

The effective drying of sugar is an important matter, since, if it be stored in a moist condition, much deterioration or "greying" results, owing to the action of bacteria developed on the sugar. A sugar store that has become infected with "greying" bacteria must be thoroughly disinfected, Tollens's formaldehyde lamp being useful for this.

Other Methods of Refining. Alcohol was suggested for refining sugar by Duncan and Newlands as long ago as 1878. The sugar was heated with alcohol when the sugar was dissolved; then, on cooling, the sugar was deposited in a pure state. Ten pounds of sugar required three gallons of alcohol. But the high cost of the alcohol and the expense due to loss are prohibitive.

In Langan's process the raw sugar is mixed with a saturated syrup so as to make a kind of artificial massecuite. The mass is drawn into a vacuum pan for the removal of small grain and any contained air. The mass is boiled to form a natural massecuite, then cooled in crystallisers to about 49° C., and subjected to a systematic washing and liquoring with saturated syrup to increase the purity. The sugar is then dissolved in the washing receptacle itself by means of a special appliance. The object of the Langan process is to prevent the waste of sugar ordinarily due to solution of the crystals in the centrifugal machines. By using saturated syrup this difficulty is overcome.

Fontenille and Desormeaux's Process. The Fontenille and Desormeaux process was patented in 1898, the claim being that by it raw sugar can be converted in less than four hours into refined sugar in pieces ready for delivery to the consumer. The method is worked in the following stages:

1. Melt the raw sugar at a temperature of from 70° to 75° C. and at a density of about 28 Beaume.
2. Add finely-powdered animal charcoal in the proportion of from 5 to 40 per cent. of the raw sugar, and mix at above temperature until the colour is discharged from the sugar.
3. Filter in press-filter, or separate the sugar in a centrifugal machine, the charcoal being recovered and washed.
4. Reheat the syrup to 75° C.
5. Pass the syrup through bag filters under pressure.
6. Concentrate, and boil to grain.
7. Pass the massecuite into moulds or crystallising apparatus, or submit to centrifugal action. If poured into moulds only one cleansing is required; if into a crystallising apparatus, the syrup is sucked away by vacuum, and one cleansing only is needed. When the centrifugal method is used the mass is cleansed in the centrifuge.
8. The mass from the crystallising apparatus, or centrifuge, is broken up and sifted, and then sent to the moulding machine after moistening with 2 or 3 per cent. of blue water.
9. The moulding machine forms the pieces of the size required for sale by pressing. The pieces are expelled mechanically.
10. The pieces are dried in a store at 60° C., either in air or vacuum.

Crosfield and Stein's Process. The Crosfield and Stein process depends on the treatment of the acid solution of sugar with peroxide of hydrogen.

The raw sugar is melted at about 160° F., and the acidity brought up to about 0·02 per cent. with phosphoric acid. The acid sugar liquor at about 27° Beaume, and at a temperature of 180° F., is treated with 0·01 to 1 per cent. of sulphate of alumina, and subsequently with 0·005 to 0·6 per cent. of tannic acid; then with 0·05 to 0·2 per cent. of phosphoric acid, this treatment partly destroying the colour. Where deemed necessary the liquor may be treated with sulphurous acid. The liquor is next filtered, and the filtrate is treated with 0·01 to 1 per cent. of peroxide of hydrogen, and phosphate of soda or ammonia in quantities of about 0·005 to 0·2 per cent.

The liquor is passed through a filter press, and the clear, bright solution boiled to crystals in a vacuum pan. The massecuite, which is very white and bright, is machined in centrifugal machines, and washed therein with concentrated syrup, or, if desired, sugar solution and peroxide of hydrogen.

Robin-Langlois' Process. By the Robin-Langlois method, patented in 1898, the fibres and dust in the sugar are removed by blowing air across a stream of sugar falling from a hopper on to a series of inclined boards. The sugar is then crushed and treated with steam in order to introduce a definite small proportion of moisture, and to brighten the facets of the small crystals. This operation is performed in the mixer for the sake of uniformity. Jets of steam or atomised water impinge against angle plates, whence they rebound on to the sugar, falling from the supply tube into the mixer in two streams.

The *mixer* is essentially an annular space between two concentric hot-water jackets, the rotating blades and sugar being contained in this space at a desired high temperature.

The discharge hole of the mixer stands above an annular trough in a revolving circular table, the circumference of the two machines intersecting to the necessary extent.

The circular table contains on its periphery a trough across which the moulds are arranged radially in juxtaposed boxes. These moulds are open at the top, and have perforated bottoms. They are locked, disengaged, and opened by special appliances which enable them to work continuously and to be emptied without injury to the bars of sugar. As the annular series of moulds revolve, they pass in turn under the discharge hole of the mixer, and are filled with sugar by inclined scrapers; they then pass on, and the sugar in each mould is compressed by a corrugated roller, fixed in relation to the table, but revolving on its own axis, so that its projections correspond consecutively with each mould. At a further stage of the revolution the moulds are automatically placed under vacuum and the syrup sucked out, and when dry they are unlocked, emptied, and readjusted continuously by the devices mentioned above.

La Fontaine's Process. In the La Fontaine method the patentee employs the reducing agents to the massecuite instead of the raw juice. Ten parts by volume of liquid sulphurous acid is diluted with 100 parts of water, and 4 litres of this liquid is added at intervals of five minutes to 100 kilos of massecuite previously diluted with molasses from a preceding operation. The mass is well mixed, allowed to rest for an hour, and then centrifugalised. When the greater part of the molasses has separated, 2 litres of the sulphurous acid solution is added by an atomiser jet to attack any colouring matter that may have escaped action and be still adhering to the crystals. By means of a perforated tube depending into the centrifugal machine, a mixture of dry steam and peroxide of hydrogen (6 vol. strength) is injected to remove any remaining sulphurous acid. After five minutes of this treatment the crystals become remarkably white and completely transparent, thus indicating their purity. Although this process does not properly come under the head of refining sugar, it is given here as indicating one of the newer methods of whitening sugar.

Ranson Process. In the Ranson process the syrup is made alkaline with barium hydrate or sodium carbonate, and hydrogen peroxide added in the proportion of from ½ litre to 5 litres per 100 kilos of sugar, according to the colour of the product. The decoloration is effected gradually. To every 100 kilos of sugar 100 grammes of powdered animal charcoal freed from phosphate is added to accelerate the liberation of oxgyen from the hydrogen peroxide by which the decoloration is effected. The excess of oxgyen is removed from the syrup by adding hydrosulphites of aluminium or barium or by producing hydrosulphurous acid in the syrup. The excess of sulphite in the syrup is converted into sulphate by adding hydrogen peroxide. The temperature is then raised to 78° C. and the syrup filtered and boiled to crystallisation.

Ultramarine. The substance ultramarine which has been referred to several times is a double silicate of sodium and aluminium, together with bisulphide of sodium. It is a beautiful blue colour, and is made by burning a mixture of sodium sulphate, china clay, and carbon in crucibles for from six to nine hours at a red heat. The dull green product thus obtained is mixed with sulphur and roasted until it assumes a bright blue colour. In the "direct" method soda is employed, and a very careful regulation of the heat of the crucibles is required for successful manufacture. Processes of washing, sifting, and drying have to be gone through before a marketable product is obtained. Ultramarine exists in Nature as lapis lazuli, and was not prepared artificially till 1828, when the above method was discovered independently by Guimet and Gmelin. Since then improvements in the manufacture have brought about reductions in the cost, and, consequently, new uses for the product have been opened out.

Treacle and Golden Syrup. When the syrups no longer yield sugar they are made into treacle, golden syrup, or invert sugar. Golden syrup is a purer kind of treacle. Of late years the quality has much improved, the appearance in many cases being artificially improved by the addition of glucose syrup. Glucose syrup is also used to prevent granulation, but in the opinion of some experts is not necessary if the sugar syrup be well inverted. The process of inverting sugar is explained in a separate lesson, either the acid process or Tompson's yeast method being used, although there are objections to Tompson's method on account of the introduction of organic matter. The golden syrup is passed through a char filter and when perfectly bright and clear is concentrated in the vacuum pan to the required viscosity.

Residual molasses of too low a quality for making golden syrup is sold to the distiller or used for cattle food.

The Refinery. The site of a refinery should be well chosen for the purchase of raw sugar, and the distribution of the finished sugar. If near a coalfield it would be an additional advantage. There should be a good supply of soft water and the cost of labour should be moderate. The blow-ups are placed on the top floor of the factory, beneath them being the Taylor filters, and lower still the char filters. The char kilns are usually in a separate building. The number of refineries has much diminished of recent years owing in a great measure to the baneful influence of sugar bounties. In 1875 there were 20 refineries in London, 9 in Liverpool, 3 in Bristol, 2 in Manchester, 1 each in Earlestown, Plymouth, and Newcastle-under-Lyme, 13 in Greenock, 1 in Leith, and 1 in Dublin; total, 52. At the present time there are approximately only 10 refineries in the United Kingdom.

Continued

Group 11
CIVIL ENGINEERING
31
Continued from page 4340

SEWERAGE & SEWAGE DISPOSAL

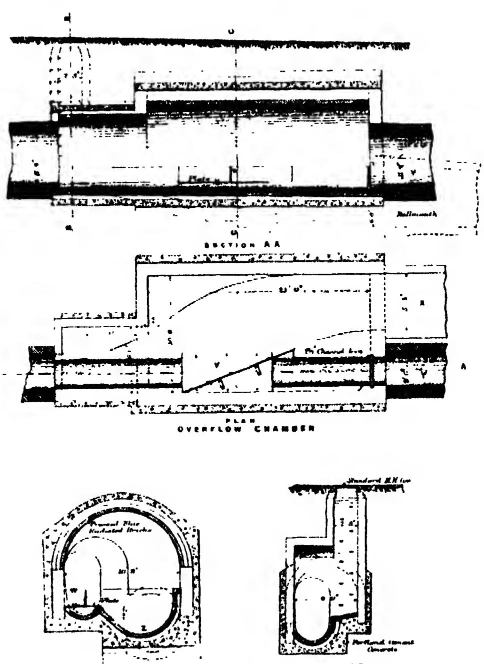
Sewerage Systems. Laying Out a Sewerage System. Sewers, Manholes, and Syphons. Pumping and Ventilating Sewers

By Professor HENRY ROBINSON

IN this course it is intended to describe briefly the principles which govern the design and execution of works relating to the sewerage of a town, and the disposal of the sewage therefrom. By the house drain the fluid refuse of a building is delivered into the public sewer, to be conveyed away for disposal as quickly as possible. In some cases several house drains discharge into a drain serving a row of houses at their backs (called a *combined drain*), and this connects with the main sewer.

Sewerage Systems. In determining the volume of sewage to be dealt with in a town, the first thing is to decide whether the whole, or only part, of the rainfall is to be admitted to the sewers. If all the rainwater is to pass into the sewers it is called the *combined system* of sewerage. If the rainwater is not admitted to the sewers, but is carried away by independent pipes, it is called the *separate* system. If the rainwater from roofs, yards, etc, is admitted—which it often is—the system is called the *partially separate*. The separation of the rainfall—or, at all events, of a considerable part of it—enables the sewers to be designed so as to be self-cleansing, and the sewage which is removed by them is brought to the point of discharge in a fresher state than is possible where the sewers are calculated to convey the larger volume, as they may become sewers of deposit in dry weather. That which is admitted should be limited, if possible, to the rain falling on roofs, streets, yards, courts, back areas, paved surfaces, etc., which may be termed *impermeable* areas. Partially permeable areas are lawns, gardens, fields, etc.

The first flow off town roads with much horse traffic (however good the scavenging may be) is very foul, and should be carried to the outfall. After this has passed away, the subsequent volume is comparatively clean water, and may be discharged by storm overflows.



1. STORM OVERFLOW CHAMBERS

Volume of Sewage. The volume of sewage to be provided for in a system necessarily depends on the rainfall, a part of which inevitably reaches the sewers. If the town has many manufactories, the fluid from which is admitted to the sewers, then provision must be made for a much greater volume. This has to be determined by an intelligent investigation on the part of the engineer, as no fixed quantity can be adopted for general application, as is shown by the fact that in forty towns in this country the volume varies from 25 gallons per head to 90 gallons per head. The factors which govern the questions are:

1. The amount of water used in private houses.
2. The amount of rainfall that is admitted to the sewers. This depends on the system, either separate or combined, which is adopted, and also upon the rainfall of the district.
3. The number of manufactories, and the volume that is discharged from them.

In calculating the amount of storm water that will enter a sewerage system the rate of rainfall has to be ascertained, especially the falls of short duration, which are more frequent and intense than those over longer periods. A study of the rain gauges in a town can determine this. An interesting paper was read at the Institution of Civil Engineers by Mr. Lloyd Davies in January, 1906, in which the results of a careful series of observations made in Birmingham over a long period are given. Only a brief reference can be made to it, and the following conclusions recorded:

(1) That the storm-water discharge from any defined district is directly proportional to the percentage of impermeable area comprised in it.

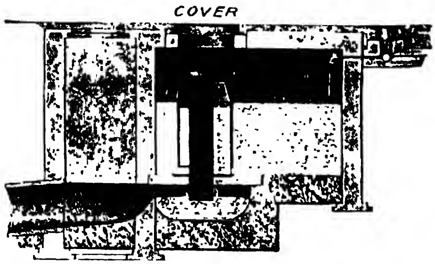
(2) That, subject to a time allowance being added for the entrance of the rain into the system, the discharge of storm water from underground channels is proportional to the aggregate rainfall during the time of concentration of the water through the

conduits, from the extreme boundaries of the district to the point of observation.

(3) That the maximum rate of flow is reached when the greatest cumulative rainfall applicable to the duration of the minimum time of concentration and to the district considered occurs.

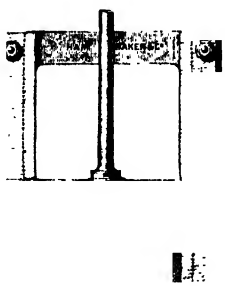
(4) That the total volume of storm water received is proportional to the maximum rate of flow.

Overflow Chambers. The design of storm overflow chambers [1] deserves a reference, and the following is a description of one adopted at Birmingham with success, and detailed observations are given in Mr. Lloyd Davies' paper.



2. THE FIELD AUTOMATIC FLUSHING CHAMBER

The overflow sill is situated at a level equal to that attained by six times the average dry-weather flow in the foul sewer. Across the foul sewer at the sill-level a cast-iron separating-plate, V, is fixed horizontally, and to this is riveted a vertical deflecting plate, W, with a hood. When the flow exceeds the volume giving the requisite dilution, the surplus storm-water is accurately separated and deflected into the relief culvert, X, the remainder passing freely under the plate, and down the foul sewer, Y. The length of the sill is arranged so that a large percentage of the overflow will fall into the tumbling bay, Z, before the plates are brought into action, and undue impact is thus avoided.

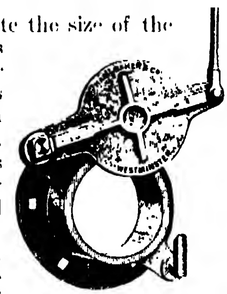


3. PENSTOCK

The reason for taking six times the average dry-weather flow is that at the present time the Local Government Board requires provision to be made for that amount at sewage disposal outfalls.

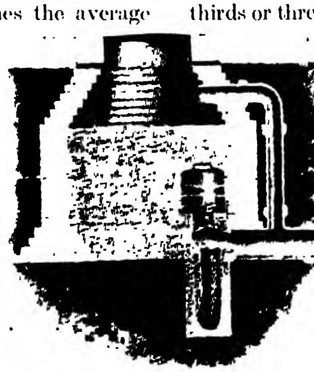
Treatment of Isolated Buildings. For isolated buildings and villages, where no sewerage system is admissible, the excremental refuse is got rid of by dry earth closets, pail, or midden system, and by cesspits. In the first-named the refuse has to be removed from the dwelling promptly, and disposed of on land in the neighbourhood, where it can be utilised for agricultural purposes. If cesspools receive the fluid refuse, they should be placed so that when filled, whatever overflows is conveyed to adjoining land of a suitable character to allow the fluid to sink quickly below the surface, and away from wells. In cesspools a septic or liquefying action takes place on the organic solids. A certain amount of solid matter, however, remains, involving the clearing out of the cesspool at stated times.

Laying Out a Sewerage System. Having ascertained what amount of sewage has to be provided for in the sewers, we now consider how to lay out a sewerage system. It is obvious that the total discharge from a town must vary during the twenty-four hours. It is usual to calculate that about one-half the flow will pass off in six hours, or about 8 per cent. per hour in the tributary sewers. The volume to be provided for in the main outfall sewer will be affected by the distances of the tributary sewers serving the various parts of a large town from the outfall sewer, and also by their gradients. The sewage from one part will reach the outfall sooner or later than from another.



4 DISC VALVE

It is usual to calculate the size of the sewer so that it runs about two-thirds or three-quarters full at its maximum flow, with a velocity of about 3 ft. per second, which, it has been decided, will carry away the usual solid matters, and prevent them depositing and putrefying. In large sewers, a velocity of $2\frac{1}{4}$ ft. per second should be obtained when they are running one-third full, $2\frac{3}{4}$ ft. per second when running one-half full, and 3 ft. per second when running two-thirds or three-quarters full. The velocity should never be less than 2 ft. per second.



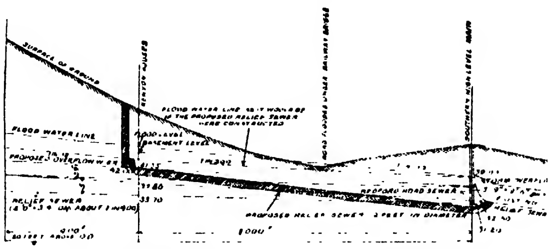
5. ADAMS FLUSHING TANK

Automatic Flushing. If the district be flat, so that the levels do not admit of the gradients giving the required velocities, automatic flushing tanks have to be adopted, or the sewage can be headed back by penstocks, placed so as to divide the sewers up into sections. The rush of fluid thus produced ensures the solid matters being carried forward. The illustration [2] shows an automatic flushing chamber with which the name of the late Rogers Field, the inventor, will always be associated.

Fig. 5 is an illustration of an Adams flushing tank fixed in a manhole.

When the manhole has to be entered for any purpose, it can be drained by removing a plug, which clears it of water.

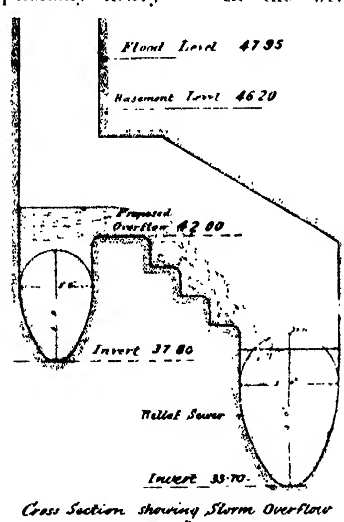
Penstock. A penstock consists of a sliding flat plate or shutter which fits into, and can move up and down in a grooved recess at the bottom of the manhole in the sewer. This sliding plate is attached to a rod, by which the penstock is put into operation. A man screws down the plate, and closes the lower part of the sewer, thus heading back the sewage, which rises behind the penstock until the sewer is filled to any height that the arrangement has provided. After a time the man returns and raises the penstock, causing the impounded sewage to pass with a rush down the sewer.



6. RELIEF SEWER AND STORM OVERFLOW

The form of penstock shown [3] is provided with a rod, and is moved up and down by means of a key which fits on to the top of the rod. For smaller sewers the same object can be attained by means of an ordinary disc valve, a form of which is shown in **4.**

Storm Overflows. In the event of sewers receiving the whole of the rainfall it is essential that provision should be made of storm overflows or relief sewers, to deal with times of floods due to exceptionally heavy rainfall acting for a short time, resulting in the sewers becoming gorged, and flooding the basements of houses. We can best emphasise this by giving particulars of a case in which the writer was engaged some years ago. A district on the south side of the metropolis had been gradually built over, but no adequate increase of the sewerage system had been made. Eventually, a heavy fall of rain occurred, which caused one of the sewers to become gorged, and houses were flooded, doing much damage. This sewer discharged into one of the metropolitan outfalls, which, being also gorged, could not receive the sewage. The writer had to investigate the matter, and a relief sewer, together with a storm overflow, were proposed. A study of the illustrations [**6** and **7**] will explain the state of affairs at the time of the flooding, and the remedies.



7. RELIEF SEWER AND STORM OVERFLOW

The diagram [**7**] shows how the gorging of the old sewer was to be remedied by providing a storm overflow when the sewage rose to a level of 42·00, when it passed away to the new relief sewer.

Size and Gradient. Having ascertained the volume of sewage to be dealt with, and the various levels of the ground and of the house drains having been recorded, we have to calculate the size and gradient of the sewer to carry away the sewage. The following formula has been adopted by the writer:

$$V = \frac{R^x}{C\sqrt[n]{S}}$$

where V = the mean velocity in feet per second, R = the "hydraulic radius" in feet—that is,

$$\frac{\text{area of water}}{\text{wetted perimeter}},$$

S = the cosecant of the angle of inclination of the hydraulic gradient $= \frac{\text{length}}{\text{head}}$,

C = a coefficient representing the roughness of the surface.

The index x, the root n, and the coefficient C depend on the nature of the surface of the channel.

For brick sewers in good condition, the value of $x = \cdot 61$, $n = 2$, and $C = \cdot 007746$. The formula for brick sewers therefore becomes

$$V = \frac{R^{\cdot 61}}{C\sqrt{S}}$$

where $C = \cdot 007746$

In the writer's book on "Sewerage and Sewage Disposal" a diagram is given, from which can be scaled the velocities, discharges, etc., of various sewers, without having to work them out by the formula.

An oval or egg-shaped sewer, instead of a circular one, has an advantage, owing to the greater velocity obtained in the contracted lower part of the oval, when the volume of sewage is at its minimum.

The internal dimensions of an oval or egg-shaped sewer are determined as follows:

If D = the internal depth of the sewer—that is, from the top of the arch to the surface of the invert,
R = the radius of the top of the sewer,
= the radius of the invert of the sewer,
= the radius of the sides—that is, the curve joining the top and bottom curves, then

$$D = x$$

$$R = \frac{D}{3}$$

$$\frac{D}{6}$$

In some cases r is taken at $\frac{1}{8}$ of D, where the sewer has to convey at times only a very small volume of sewage, as the contraction of the invert tends to prevent deposits by increasing the depth of sewage, and consequently improving the velocity. If the volume of sewage be subject to great fluctuation, so that at times it is very small, the egg-shaped or oval sewer is preferable to the circular form. Where the sewage generally half fills the sewer, the oval shape loses this advantage, and the circular shape is cheaper to make, while it is also stronger.

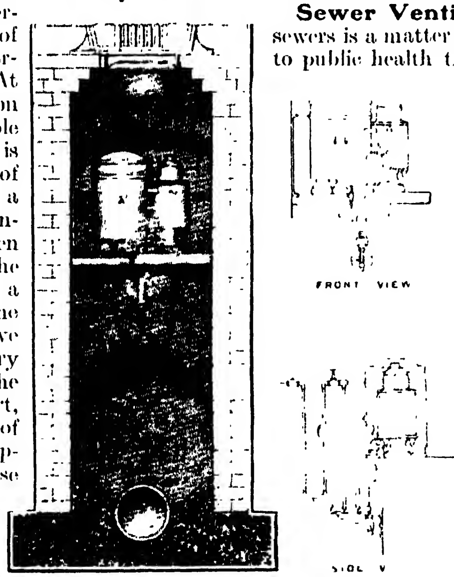
8. SEWER SYPHON

The thickness of sewers varies with the size, the nature of the ground, and the depth. A $4\frac{1}{2}$-in. ring of brickwork suffices for the smaller sizes in good ground. In larger sewers the thickness varies from 9 in. upwards. The thickness can be calculated by the formula

$$\frac{D \times R}{100} = \text{thickness of brickwork in feet,}$$

where D = depth of excavation, and R = external radius of sewer.

Manholes. Sewers must be laid in straight and not curved lines. The invert of the sewer must also be a straight line. Any alterations or depressions both interfere with the flow of sewage and assist the formation of deposits. At every change of direction of the sewer a manhole should be placed. This is carried to the surface of the road, and enables a man to go down and inspect the sewer between the manhole in which he is and the next one, a light being placed in the latter. It is usual to have means of inspection every 100 yards so that if the manholes be farther apart, owing to a long piece of straight sewer, a lamphole is placed at these intermediate points. Lampholes are small, vertical iron or stoneware pipes carried up to the road level so as to enable a man to lower a lantern to the sewer at that point.



9. REEVES VENTILATING APPARATUS

Syphons. When the sewer has to be carried under the bed of a stream, either in the form of a syphon or in the continuation of the gradient, it is best to make it of cast iron, as the flanged pipes can be bolted up on rafts or barges, lowered into position quickly and covered. Fig. 8 shows a syphon carried out by the writer in this way.

The syphon was tested by water pressure to see that it was sound, and the trench was filled with concrete, by means of wooden funnels, to prevent the stream washing away the cement. A copper wire cord ought to be passed through the syphon before it is put into position, and left there permanently to admit of a scraper being drawn through at any time the pipe may get blocked.

Open Grids. Covers are placed over all manholes and lampholes, with open grids or gratings in them for ventilation. These grids should form part of a system of ventilation acting as inlets for fresh air, the outlets consisting of iron pipes carried up the sides of houses or trees, and away from windows, or columns in the road placed at shelters, etc., and at a height sufficient to cause any foul gas to be diffused above people's heads. In certain cases these open grids have to be sealed. Some advocate the abolition of the trap on the house drain, so that the soil-pipe will act as an upcast for the foul air from the public sewer. This is open to the objection that the private house will then be receiving the objectionable sewer gas, which should be dealt with in some systematic and intelligent way by the public authority.

Sewer Ventilation. The ventilation of sewers is a matter of such importance in regard to public health that it deserves full consideration, and reference will be made to systems which have been employed to prevent the obnoxious gases which are generated in sewers from causing injury to the health of those who are exposed to their emission from gratings, or otherwise. In some cases surface gratings cannot be regarded as a solution of the problem even with upcast shafts, as the atmospheric conditions may at times be unfavourable to the removal of the foul air by means of the upcast. If the sewers have proper gradients and are self cleansing, the usual provision of gratings and upcast shafts will ensure the proper change of air; but there are many cases where the conditions do not exist, and it is well to record how to prevent sewer air, under such circumstances, from being a danger to health. One system which has been employed with success is called the Reeves system.

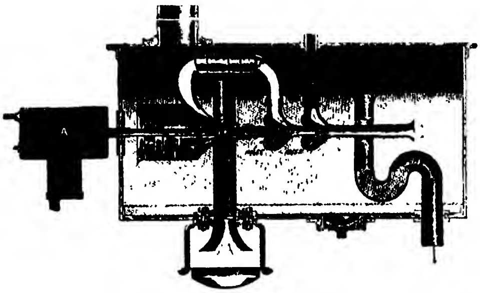
This is based on the use of chemicals in the sewers, whereby the noxious gases are deprived of their injurious properties. Fig. 9 will explain how this is effected.

A ventilating apparatus has been brought out by Messrs. Stone & Company which deserves mention. Fig. 10 shows the apparatus in a

tank ready to be fixed in the sewer, the foul gases in which it is desired to neutralise.

Fig. 11 shows the apparatus fixed in the sewer ready for use.

Construction of Sewers. In the construction of brick sewers only well-burnt and well-shaped bricks should be used, and they should be well soaked to prevent their absorbing



10. STONE'S VENTILATING APPARATUS

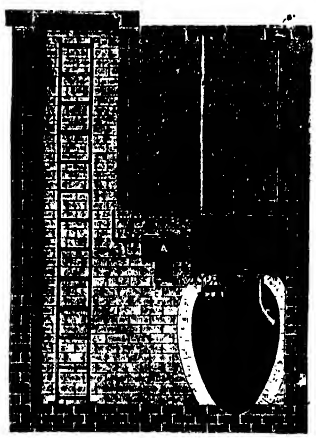
water from the cement. The sewer invert should have a smooth and hard surface to diminish friction and to prevent erosion. Blue Staffordshire bricks, glazed fireclay bricks, or hard blocks well glazed on the surface are generally used for inverts. The bricks should be radiated to suit curves so that no more mortar is used than is necessary to make the joint. The mortar should be made of one part of best well-seasoned Portland cement to one of clean, sharp sand. Good hydraulic lime or blue lias lime is sometimes used. The materials require great care in selecting, and the mortar should be used as soon as mixed. Brick sewers are sometimes built in sections in wooden moulds.

Where the nature of the ground requires it, a brick sewer should be strengthened by encasing it partly or wholly with cement concrete, and if there are several rings of brickwork a "collar joint" of cement about 1 in. thick between each ring ensures the watertightness of the work. The joints of brickwork should not be too thick, the faces being not more than ¼ in. apart. The trowel should be passed over the mortar to increase its density. The work ought not to be exposed to contact with water until it is well set. In very wet ground a subsoil drain should be placed under the trench to take away the water to the pumps, instead of its running at the bottom of the trench to the pumps. If the sewer be made where any settlement of buildings may occur great care should be taken to timber the trenches well, and even to leave the bulk of the timber in, in order to avoid the risk of subsidence.

Concrete Sewers. Some very good sewers have been made entirely of concrete consisting of six parts of gravel and sand free from earthy matter to one part of Portland cement. The invert of the sewer is first built, then concrete is well rammed behind a mould with a smooth surface—formed of sheet zinc or other material—and the top of the sewer is turned upon centres. If the interior be well rendered with cement, a good sewer can be made, provided the best well-seasoned cement and perfectly good materials are employed, otherwise concrete is liable to crack.

Stoneware Pipe Sewers. Stoneware pipes can be used for sewers up to 21 in. in diameter. Beyond that size sewers are generally made of brickwork, as the handling and jointing of pipes of large size results in their costing as much as brick sewers. Stoneware pipes should be made of good vitreous material having a clear ring when struck and having strength to stand shocks and strains. They should be well burnt at a high temperature with a salt glaze which permeates the body of the pipe and renders it impervious. They can be tested for impermeability by closing the lower end and filling the pipe with water. Any lowering of the water will disclose defects. By drying a pipe and weighing it, and putting it in water for a while and re-weighing it, a test of impermeability can be made.

The joints of ordinary stoneware pipes should be carefully made so as to be watertight. This requires the enforcement of certain well-known conditions. The bed has to be prepared on which to lay the pipes, with spaces taken out to receive the socket, so that the whole length of the barrel is supported. Where the ground is not thoroughly sound and solid, a bed of cement concrete about 6 in. thick should be laid at the bottom of the trench, with similar spaces for the socket. This layer of concrete can be carried up after the jointing is finished, so as partly or wholly to encase the pipes, according to circumstances. After the end of one pipe has been placed in the socket of the other it should be butted home and tarred gaskin should be caulked up to the face. The joint is then completed by filling the space with cement finished off neatly by a fillet outside. Either neat Portland cement or half-clean sharp sand and half cement can be used, but not clay. A properly made joint depends first on the pipes butting home, then on the gaskin being caulked up to the face of the socket, and, lastly, on the ring of cement being of equal thickness all round.



11. STONE'S VENTILATING APPARATUS IN SEWER

Special Joints for Stoneware Pipes. There are means of jointing stoneware pipes other than the ordinary way which has been described. The earliest departure was the Stanford joint, which was formed by the contact of two conical surfaces cast outside the ends and

inside the sockets of the pipes. The surfaces, when in contact, were relied on to make a watertight joint, and were found of service where sewers had to be laid in ground with much water. Such joints require the sewer to be much supported, as any settlement draws the joint. Improvements have been made on this by casting the ends of the pipes with annular rings on both spigot and faucet. These can be filled with liquid cement poured in through holes in the top without risk of its being washed out or disturbed, as is the case with ordinary cement joints. The "Hassall" was the first joint based on this principle.

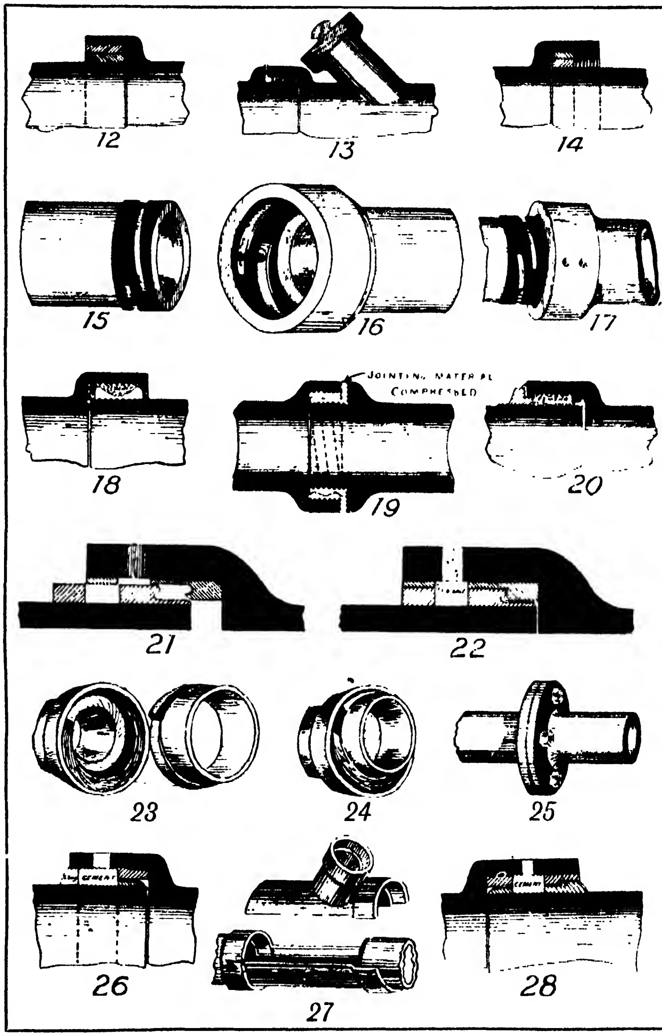
There are many more recent arrangements which have been patented for making joints in stoneware pipes, and we shall refer to some of them.

In making a tarred gaskin and cement joint in an ordinary stoneware pipe, dependence has to be placed in the barrel being kept in the right position by hand until the gaskin is rammed in at the bottom to ensure that the spigots and faucets of the pipes are in their right positions. If this is not done properly the space that has to be cemented may be greater at the top than at the bottom. The writer once inspected a long length of leaky stoneware sewer, where he found that the leaks were caused by the absence of any gaskin and cement at the bottom. Many forms of joints have been devised to prevent this, and some are shown from **12** to **28**.

Stanford Joint. Fig. **12** is the Stanford joint, the spigot end of which is provided with an annular bituminous band, which fits truly into a similar band in the socket. These bands are greased over before the spigot end is driven home, thus forming a watertight joint. Fig. **14** shows another form of this joint, where the bands are only half the width, thus permitting the joint to be finished with a fillet of cement.

Sykes Joint. The Sykes joint shown in **13** has been extensively used by the writer. The spigots and sockets of the pipe are provided with bituminous rings which, when in position, form a groove into which liquid cement grout is poured. The illustration also shows a screw stopper for plugging temporarily the branches on the main sewer provided for house junctions. Another form of Sykes joint is shown in **19**.

The Spiralitic Joint. This is a recent form of joint [**15**] in which the spigot end of the pipe has a band of bituminous compound cast round it, having a groove in it of a spiral or screw shape. The socket [**16**] is lined with a similar band of material also having a spiral groove. The socket has two holes side by side, one connecting to each end of the groove. When the spigot end is pushed home the two grooves form a cavity into which liquid Portland cement is poured in at one hole until it appears at the other, which shows that the spiral cavity is filled.



SEWER JOINTS

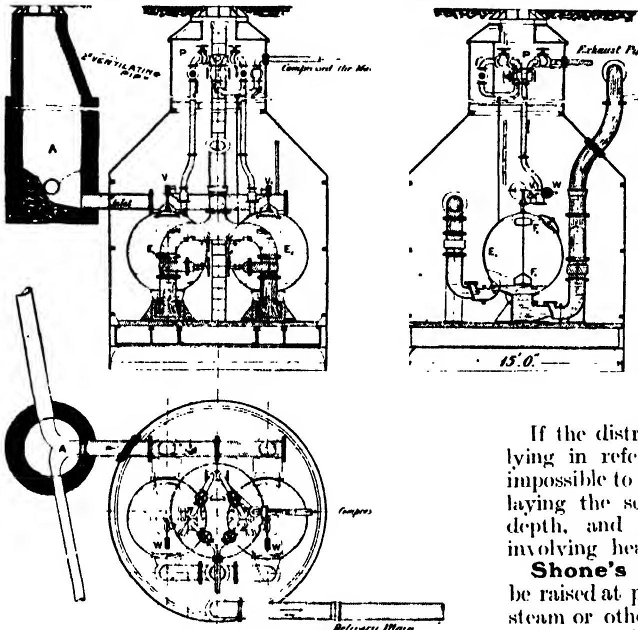
Other Pipe Joints. Parker's safety pipe joint is another form of joint for stoneware pipe sewers. Fig. **18** shows its construction.

The Archer eccentric pipe joint, as shown in **20**, is in substitution for the old joint of the same patentee, which was abandoned some years ago.

Brown's hydrotite joint is another arrangement, and is shown in **21** and **22**.

The Freeman-Hines joint [**23** and **24**] is a new form of joint, effecting rapidity of laying with watertightness. On to the spigots of the pipes

and to the faucets of the sockets are cast bituminous eccentric bands, which, when brought together and slightly twisted, form a small

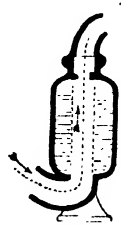


29. SHONE'S EJECTOR

cavity which, after being filled with bitumen, completes the joint.

Wakefield's insertion pipe or junction, as shown in 27, is useful when the barrel of a sewer has to be broken in order to form a house connection.

Hassall's single lined joint is somewhat similar to the Stanford joint, except that the sockets are much deeper. The spigot ends and sockets are provided with narrow bands of bituminous compound. The spigot end, after being pushed home into the socket, leaves a space which is filled with cement as shown in 26.



31. SECOND TRAP

Hassall's two-lined joint is shown in 28.

Cast-iron Sewers. In some cases it is found necessary to employ cast-iron instead of stoneware pipes for sewers. The usual method of jointing cast-iron pipes is that shown on page 4340. It is sometimes found more expeditious to use a turned and bored joint.

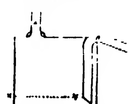
Another form of joint for cast-iron mains is shown in 25, and is the one generally used for syphons under rivers. The faces of the flanges are usually machined, the joint being completed by a rubber ring placed between the flanges preparatory to their being bolted together.

Sewage Pumping. In laying out a sewerage system, care should be taken to avoid unnecessary pumping if the levels involve the sewage being lifted to reach the outfall. In some cases the higher part of a district can discharge its sewage by a gravitation sewer, leaving only the lower part to be pumped, instead of bringing the sewage from the high district down to the low. The size of the "rising main," which conveys the pumped sewage, should be calculated so that the velocity in it conforms to what has already been stated as necessary to prevent the deposition of solids. If the rising main pass over a summit, an automatic air-valve should be placed there to prevent an air lock. Fig. 32 shows one manufactured by Messrs Ham, Baker & Co.

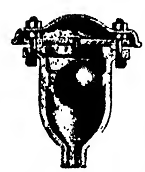
It is advisable to place a back-pressure or reflux valve [35] on the rising main near the pumping station. This prevents a rush of sewage taking place should a breakdown occur at the pumps.

If the district to be sewered be flat, and low-lying in reference to the outfall, it is often impossible to get the necessary gradients without laying the sewers in places at a considerable depth, and perhaps in waterlogged ground, involving heavy expense.

Shone's Ejector. When sewage has to be raised at places where the establishment of a steam or other kind of pumping station might be undesirable, or would raise opposition, the power necessary to lift the sewage at such points can be developed at any convenient spot at a distance, transmitted to these points, and applied to suitable lifting machinery placed in chambers beneath the surface of the ground. One appliance that is much employed is Shone's ejector [29], of which the following is a description.



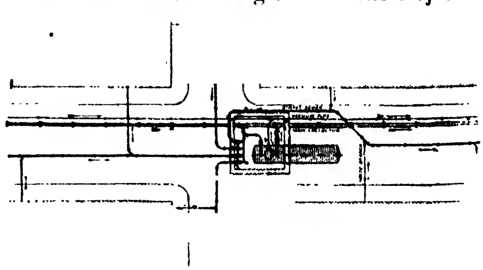
30. FIRST TRAP



32. AUTOMATIC AIR-VALVE

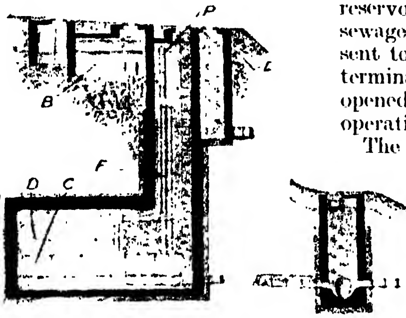
This is an automatic arrangement by which compressed air is applied to the surface of the sewage, collected in an airtight receiver from any number of low-level sewers. The pressure of air forces the low-level sewage from the receiver to a sewer at a higher level which conveys it to the outfall.

The illustration [29] shows a recent installation of this system consisting of two ejectors, E and E¹, placed in a circular cast-iron chamber, constructed below the ground. These ejectors



33. RESERVOIR ON THE LIERNUR SYSTEM

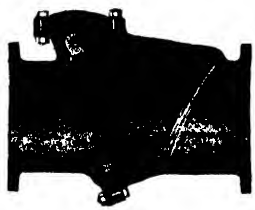
work alternately, being regulated by an ingenious arrangement of valves at P. The admission of compressed air, and also the exhaust air from the receivers, are controlled by automatic air valves V^1 and V^2, actuated by floats, as shown by F^1 and F^2 in the ejector, E, attached to rods which are connected to weighted levers, W. This device is arranged so that when the receiver is empty, its floats assume their lowest positions. As the incoming sewage rises, and eventually submerges the top float, the equilibrium of the lever is disturbed by the floats rising, causing the weight, W, to drop, thus operating a slide valve which admits the compressed air to the surface of the sewage, collected in, and filling the receiver. The contents of the receiver are then rapidly removed and discharged into the high-level sewer. The floats, falling with the sewage, cut off the compressed air supply, and also open an exhaust valve, which releases the expended air in the receiver.



34. ADAM'S SEWAGE LIFT

The Liernur System. The removal of the fluid refuse from houses by this system is effected by pneumatic agency. It was adopted many years ago at Amsterdam, where the writer saw it in operation with the late Captain Liernur. The system has been more recently successfully adopted at Trouville in France, Leyden in Holland, and at Stansted in Essex. The sewers have to be, of course, airtight, and are of iron.

Where a sewer receives solid matters which may deposit, as is the case especially in Oriental cities, where the underground conduits connecting with the sewers receive much coarse material, it is claimed that the Liernur system meets the difficulty.

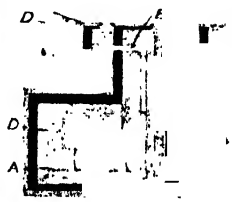


35. REFLUX VALVE

Fig. 33 is a diagram of a district reservoir into which the sewage from the area which it serves is discharged by this system.

Each district reservoir is constantly in connection with the vacuum pipe, in which a vacuum of not more than half an atmosphere is constantly maintained by the engines at the pumping station; and, in order that everything may be entirely removed from the district pipes and the house receptacles, these are put once a day into communication with the district reservoirs, with which they are connected. This is done by a man first proceeding to close the cocks R and opening the cocks M, thus establishing the communications with the vacuum pipe, which is always under depression, and the reservoir. He then proceeds to open the cocks R one after the other. As he does so the atmospheric air rushes through the soil pipes, or air inlet, causing strong pressur to be exercised in the matter in the receptacle R, and forcing the same into the street sewers and the reservoirs. After that, cocks R are closed again and tap A is opened, this making the communication with the main sewer (under vacuum), opening at the same time an air inlet over the reservoir, by which means the whole of the sewage collected in the district reservoir is sent to the main station. The operation being terminated, tap A is closed and taps R again opened, and ordinary conditions restored. The operation takes ten minutes.

The maintenance of the eals of the house traps is effected as follows. The first trap into which all the house liquid first passes is formed as shown in 30. A is the inlet, B the outlet. When the vacuum is brought into action the contents will be reduced to a level slightly above that of the line X Y, as shown, because the air will force itself through a small depth of water seal, and the water always remains above the level X Y.



The second trap is formed as shown in 31, being simply an enlargement of the soil pipe. During the action of the vacuum the fluid passes in the direction of the arrows, but the concentric ring of liquid between the dotted lines and the periphery of the trap is not drawn off, and hence remains to fall back after the pneumatic action is over, and to form a new seal.

Adams Sewage Lift. By this system, sewage in a sewer at a high level is utilised to lift sewage from a low level automatically, and thus save pumping. Figs. 34 and 35 show the working of the system.

The sewage lift is actuated by air compressed by a column of sewage, the only moving parts required being the inlet flap valves. The distance between the air and forcing cylinders is immaterial. In all cases the sewage to be raised gravitates to the "forcing cylinder," A, entering it through a non-return flap valve. Liquid is fed to a flush tank, B, in the air chamber and discharged through its pressure pipe, P, to the air cylinder, C, displacing the air therein, which passes by an air-pipe, D, to the forcing cylinder, A, exerting there its pressure upon the sewage to be raised, the latter being discharged through the rising main, E, into the intercepting sewer The air cylinder, C, when full, is emptied into the intercepting sewer by means of a syphon, F.

Continued

Group 14 **METALS** **5** Continued from page 4307	# IRON AND STEEL **Varieties of Iron: Cast Iron, Malleable Cast Iron, Wrought Iron and Steel. Iron Ores and their Composition**

By A. H. HIORNS

IRON is by far the most useful and the most used of all metals in virtue of its special properties, especially its great strength, its abundance in the earth, and its low price.

Varieties of Iron. It occurs commercially in different forms, and, with the aid of foreign bodies, possesses widely different qualities. In one case it is easily melted and cast, very brittle when solid, and cannot be forged. In another case it is soft at a white heat, easily forged and welded, offers considerable resistance to sudden shock, is almost infusible, and retains its softness after sudden quenching in water. In yet another case it is malleable, highly tenacious, and can be made intensely hard by sudden quenching in water. These widely divergent properties enable it to be employed in a greater variety of circumstances than any other metal. Up to about 50 years ago only three kinds of iron were recognised—cast iron, steel, and wrought iron—but at present a greater number of different kinds are manufactured, varying in properties with the nature of the foreign elements they contain, which really convert the pure iron into an alloy. Of these foreign bodies by far the most influential is carbon.

All kinds of iron may be classified under two chief heads:

MALLEABLE: Wrought iron and ingot iron; wrought steel and ingot steel.

NON-MALLEABLE: Pig or cast iron.

The difference between iron and steel is marked by the hardening or non-hardening properties. In wrought metal the structure is obtained by mechanical treatment at a welding temperature. In ingot metal the product is cast into moulds from the liquid condition. Ingot iron, in consequence of its non-hardening property, is also termed "mild steel."

Pig or Cast Iron. Pig iron is obtained by smelting iron ore with charcoal, coke, or raw coal in a blast furnace. Two chief varieties are obtained, dependent upon the furnace conditions and nature of the charge, termed grey and white irons.

Grey Pig Iron. Grey pig iron consists essentially of iron, carbon and silicon, but other elements, such as phosphorus, manganese, and sulphur are frequently present. The carbon generally varies between 2 per cent. and 4 per cent., and the silicon from 1 per cent. to 3 per cent. The peculiar character of grey iron is due to the mode of occurrence of the carbon, which is influenced by the amount of silicon present and the rate of cooling. Silicon tends to cause the carbon to crystallise out in the form of graphite. By very slow cooling these crystals become very large, and by quicker cooling, very small. Grey iron is, therefore, not one uniform mass like white iron, but it contains different bodies mixed together, the size of the grain largely determining the strength. With large flakes of graphite the iron approximates nearer in strength and malleability to wrought iron. Grey iron requires a higher temperature to melt it than white iron, becomes thinly liquid when melted, and expands when solidifying, which admirably adapts it to castings. It is also produced at a higher temperature in the blast furnace than white iron, which tends to make it more impure.

White Pig Iron. White pig iron contains its carbon chiefly in the combined form, is freer from silicon, and often contains more manganese than grey iron. It is a true alloy of iron with carbon, phosphorus, manganese, etc. It is intensely hard and very brittle. With much manganese, from 5 per cent. to 20 per cent., it is composed of large crystalline plates and termed *spiegel-eisen*. When the manganese content considerably exceeds 20 per cent., the crystals are much smaller, and the alloy is termed *ferro-manganese*. White iron is produced when the furnace is charged with a heavy burden of slags mixed with ore, and is then termed *cinder pig*, as distinguished from iron produced entirely from ore. White iron is also produced from easily reducible ores, which require less fuel than ones reducible with greater difficulty.

Mottled Iron. Mottled iron is intermediate between grey and white iron, and partakes of the properties of both. When broken, it shows a veined or mottled appearance. Pig iron is arranged into a variety of classes according to the colour, texture, size of the crystalline plates, and general character of the fractured surface. It is graded in numbers from 1 to 8, or more commonly from 1 to 4, for foundry purposes, and number 4 forge, mottled and white. No. 1 is the greyest and the richest in silicon. Passing from No. 1 to white iron the combined carbon gradually increases and the silicon diminishes.

The term *cast iron* is used to express the metal obtained by remelting pig iron and casting it into moulds of various kinds in the foundry. The greyer varieties of pig iron are termed *foundry pigs* and the others *forge pigs*, the latter being used chiefly for the production of wrought iron.

German Cast Iron. In Germany the following kinds are produced:

WHITE PIG IRON			
Ferro-manganese.	White Iron Proper.		
	Spiegel.	White.	Ordinary.
30 to 80 per cent. manganese	5 to 20 per cent. mangan-ese	1 to 5 per cent. mangan-ese	Less than 1 per cent. mangan-ese

GREY PIG IRON		
Half pig.	Deep grey.	Silicon iron
0 to 3 per cent. manganese 0·5 to 1·5 per cent. silicon	0 to 5 per cent. manganese 2 to 4 per cent. silicon	5 to 17 per cent. silicon

Malleable Cast Iron. When cast iron articles, produced from high class white iron, are embedded in powdered hæmatite, packed in iron cases, and heated to a cherry red heat for a few days, they become malleable, and are said to be annealed. By this action the combined carbon is set free, and some of the carbon is burnt off from the surface, which renders the cast wares malleable.

Wrought Iron. Wrought or malleable iron is a mixture of iron and slag, drawn out into fibres by mechanical treatment at welding temperatures. There is, however, this difference, that the iron is crystalline and the slag amorphous. Wrought iron is not pure, but contains, in addition to the slag, those elements in a smaller degree which are present in the pig iron. It possesses the welding property in a high degree. Its specific gravity is 7·8, and its melting point about 1,600° C.

Steel. This is a malleable and tough alloy of iron and carbon, the latter not exceeding 2 per cent., and generally less than 1·6 per cent. In special steels, elements such as manganese, nickel, tungsten, chromium, etc., are added in various amounts. When the carbon is less than 0·3 per cent. it is termed *mild steel*, and cannot be materially hardened by sudden quenching. Steel is finely crystalline in structure, and the higher the percentage of carbon the smaller the grain. The carbon exists chiefly in combination, forming the compound Fe_3C. Steel has a bluish-white colour, is generally destitute of fibre, except in wrought steel, and possesses great strength and tenacity. It can be made intensely hard by sudden quenching and again softened by slow cooling from a red heat. By cautiously re-heating hardened steel to 200° or 300° C. the tension is released, the metal loses its brittleness, and its intense hardness is modified. This is termed *tempering*. Hardened steel is capable of retaining its magnetism after being once magnetised, especially the variety known as *tungsten steel*.

The Early History of Iron. We can only conjecture when iron was first extracted from its ores and applied to the use of man. The most ancient samples have been obtained from Egypt and Assyria, some of them assumed to be 4,000 years old. When the Roman Empire was extended, the use of iron became widely known. Pliny mentions the hardening of steel by quenching in water and in oil. For centuries before the Christian era, iron was produced, and what is now known as *Styrian* and *Noric* iron was famed for its high quality. The ancient Britons were acquainted with the use and probably the extraction of iron, and during the Roman occupation the manufacture was enormously increased in the country.

In all ancient processes the iron was obtained from the ore in one operation. This is known as the *direct method*, and is the one still employed in some parts of India, China, Africa, South America, and, to a limited extent, in Europe. The furnace is a simple open hearth or small blast furnace. The fuel used is charcoal, and the blast is obtained by rude blowers or bellows. In the fourteenth century cast iron began to be obtained in small blast furnaces. All ancient iron furnaces were heated with charcoal. The increase of iron smelting in this country produced a scarcity of charcoal, which directed attention towards the use of coal and coke. Dudley, in 1619, produced pig iron from ore smelted with coke. This led to a practically new industry, that of coke making, which has been associated with that of iron smelting ever since. The invention of the steam engine led to the use of blowing cylinders for the production of the blast, which was obtained at high pressure and greatly increased the yield of iron.

Improved Processes of Refining Iron. In 1784 a great improvement in the method of refining pig iron was made by Henry Cort. Before that time iron was purified in small hearths with a great expenditure of fuel, but Cort's introduction of the reverberatory puddling furnace lessened the fuel consumption and enabled coal to be used instead of charcoal.

Another marked advance was made by Neilson, in 1828, by the substitution of hot for cold blast. This was soon followed by closing the top of the blast furnace, so as to collect the waste gases and utilise them for heating the blast.

In 1840, Huntsman greatly improved the manufacture of crucible steel. In 1855, the great inventions of Bessemer were given to the world, and in 1861, Siemens invented his regenerative furnace. In 1878, the introduction of the basic process of steel-making was made by Thomas and Gilchrist, and is now employed in the *Bessemer* and *Open Hearth* methods.

In recent years the development of the blast furnaces has resulted in increased height and capacity, greater facilities for charging, discharging, casting, and dealing with the pig iron obtained. In steel-making the great feature has been the invention of new types of open hearth furnaces, and in methods of treating, working, and using them.

Great improvements have been made in machinery, chiefly electrical, rather than in processes. The tilting furnaces of Campbell and Wellman for continuous practice, and the

Bertrand-Theil duplex method of working are the most prominent. Many kinds of special steels have been recently introduced, which require special treatment, and these have revolutionised machine shop practice.

Ores of Iron. Iron occurs in Nature in small quantities in the metallic state as meteorites, but the oxides and carbonates form the chief source of the metal.

Magnetite is a black oxide of iron, Fe_3O_4, and possesses magnetic properties. It contains, when pure, 72·4 per cent. of iron. Although occurring in various parts of the world the chief supply is obtained from Sweden and North America. From this ore the celebrated Swedish iron is obtained.

Hæmatite is the red oxide, Fe_2O_3, and contains, when pure, 70 per cent. of iron. It occurs in a variety of forms as *specular*, *micaceous*, *kidney*, *ochre* and *massive* hæmatite. The most important deposits in this country are in Cumberland.

Brown hæmatite, or limonite, is of a brown or yellow colour, and consists of Fe_2O_3 with combined water. It may be typically represented by the formula $2Fe_2O_33H_2O$. It is abundant in the English Midlands and various parts of the world.

Spathic ore, *chalybite*, or *siderite* is a carbonate of iron, $FeCO_3$, containing, when pure, 48 per cent. of iron. It is abundant in the Midlands, South-West and Northern counties. It occurs in enormous masses in Scandinavia, Central Europe, and North America. Clay ironstone and Blackband are varieties of this ore.

Iron pyrites, FeS_2, although it is very abundant, is not suitable for smelting on account of the sulphur which it contains. When heated in air or oxygen the surface becomes coated with the black oxide, Fe_3O_4. Iron is readily attacked by hydrochloric or dilute sulphuric acid, hydrogen being given off and chloride or sulphate of iron formed. If concentrated sulphuric acid be employed the metal is oxidised at the expense of the acid and sulphur-dioxide is evolved. Ordinary nitric acid attacks iron vigorously; but if the acid be concentrated the iron becomes passive.

There are three oxides of iron of metallurgical importance—ferrous oxide (FeO), ferric oxide (Fe_2O_3), and magnetic oxide (Fe_3O_4). Ferrous oxide is very unstable and rapidly oxidises in air; it unites with acids to form iron salts and is the principal base in all slags formed in the refining of crude iron. In combination with carbon-dioxide it forms spathic ores. Ferric oxide occurs native. It is a fairly stable compound, but at a white heat it gives up oxygen, forming Fe_3O_4. The magnetic oxide is the richest ore of iron; it is produced when iron is strongly heated in air, oxygen, or superheated steam, and is used as a protective coating from further oxidation of iron goods. The influence of silicon, phosphorus, sulphur, carbon, etc., is dealt with elsewhere.

Production of Pig or Cast Iron. Most iron ores are first calcined in heaps, stalls, or kilns, with the addition of a little fuel. The object of this is to remove water, sulphur, carbon, dioxide, and other volatile matter, to convert ferrous into ferric oxide, and to render the ore more porous and more readily susceptible to the action of the reducing agents in the blast furnace.

The calcined ore is put into the blast furnace with coal, coke, or charcoal, and a flux, which is generally limestone. About four tons of material will produce one ton of iron. Air is forced in at the bottom and rises towards the top; it thus encounters the solid materials which are descending, and by acting upon them, liberates the iron. The oxygen of the air combines with the carbon, and produces the necessary heat. The carbon and the carbon compounds formed reduce the iron oxide. The flux unites with the gangue of the ore, and forms slag. Thus we have the heat-producing action, the reducing action, and the slag-forming action.

TYPICAL COMPOSITION OF IRON ORES

—	Swedish Magnetite	Cumberland Hæmatite	New South Wales Hæmatite	Northampton Limonite	Styrian Spathic	Staffordshire Clay Ironstone	Cleveland Ironstone	Blackband
Ferrous oxide ..	59	—	—	—	51	47.5	40	41
Ferric oxide ..	28	93	73	65	—	—	3·5	2·5
Manganese oxide	0·1	0·2	—	0·5	5·5	0·9	1·0	1·0
Alumina	0·3	0·6	4	3·5	3·5	4·8	7·5	3·0
Lime	0·4	—	1·7	2·5	0·9	1·9	7·5	2·0
Magnesia	0·1	- -	0·9	—	0·8	1·9	4	1·0
Silica	12	5·56	10	13·2	0·26	10	9	7·0
Carbon dioxide ..	0·1	—	-	—	38	31	23	26·0
Phosphoric acid ..	0·03	0·04	–	1·3	0·04	0·05	1·8	0·5
Sulphur	—	–	–	—		—	0·11	—
Water	–	0·6	10·4	14		1·95	2·5	1·0
Organic matter ..	—	-		—		—	—	15·0

Chemistry of Iron. Pure iron may be produced in two ways:

1. By reducing pure ferric oxide by hydrogen in a porcelain tube at 700° C., when it is obtained as a dark powder. If the reduction is effected at a much higher temperature a silver-grey, spongy mass is obtained.

2. By the electrolysis of a solution of pure ferrous chloride or sulphate.

Iron is unaltered in dry air, but in the presence of moisture it rusts, forming a hydrated oxide. The oxidation is probably accelerated by the presence of carbonic acid. When it is strongly

Necessary Conditions in Iron Reduction. In order completely to reduce oxide

of iron, we must have a high temperature and contact with a deoxidising substance, such as carbon, carbonic oxide, etc. The reduction of oxide iron by carbon yields carbonic oxide, in which form it escapes, but the reduction by carbonic oxide yields carbon dioxide. These reductions may be expressed by the following equations:

$$Fe_2O_3 + 3C = 2Fe + 3CO;$$
$$Fe_2O_3 + 3CO = 2Fe + 3CO_2$$

Under the strongly reducing conditions required for the reduction of oxide of iron, elements other than iron are also reduced, such as phosphorus, sulphur, silicon, manganese, etc., and these combine with the iron. The fuel also contains sulphur, and sometimes phosphorus, and these contribute impurities to the iron. By contact with incandescent carbon also iron absorbs some carbon.

"Direct" Methods. Similar reactions take place when primitive or direct methods are used, but these are now employed only to a limited extent. In these furnaces a relatively low temperature and a short contact of the iron with the carbon prevents a little of the latter from uniting with the iron, and by the oxidising action of the blast the combined carbon is largely removed, and a pasty mass of metal, termed the *bloom*, is obtained and hammered into a malleable mass of wrought iron. By keeping the bloom longer in contact with incandescent carbon, a steel or steely iron is obtained. Such a method is termed *direct*, because iron is produced in one operation instead of in two, as in the blast furnace method, where pig iron is first produced, and then refined in the puddling furnace.

Direct methods can be applied only to very rich ores with little gangue, and charcoal is necessary as fuel. In addition to this, the labour is very great, and the loss of iron in the slag considerable. These conditions have led almost to the abandonment of the process. In order to prevent waste of iron, limestone is necessary as a flux, which forms a slag with silica; but this requires for its formation a high temperature, such as that of the blast furnace.

Molten Iron. It has been mentioned that the conditions in the blast furnace are favourable to the absorption of carbon by the iron, and the pig iron obtained contains 3 to 4 per cent. This, having a lower melting point than malleable iron, becomes perfectly liquid at the temperature of the furnace, and on account of its specific gravity falls to the bottom. The slag also is melted, and floats on the top of the iron, the gaseous products escaping at the top. In a general way the reactions may be expressed thus:

$$2Fe_2O_3 + SiO_2 + CaO + 3C = 4Fe + CaOSiO_2 + 3CO_2$$

But the reactions are not nearly so simple as this. Carbonic oxide plays an important role; the gangue of the ore contains alumina, magnesia, oxide of manganese, phosphoric acid, etc., so that the slag is a complex silicate. The escaping gases contain also nitrogen, carbonic oxide, hydrogen, and other volatile matters. It will be understood, then, that temperature is an important factor in determining the character of the reduced iron.

It is possible in the blast furnace to treat much poorer ores than in the forge furnace; the slag is almost free from iron, and the manual labour much less. Since pig iron is aimed at, coal and coke can be used instead of charcoal as fuel. In the forge furnace, also, 3 or 4 tons of charcoal are required for the production of 1 ton of malleable iron, while in the blast furnace 1 ton of pig iron can be produced with 1 ton of coke. It is true that pig iron has to be refined, but the combined cost of reduction and refining is much less than a single operation in the forge furnace.

Principles of Blast Furnace Practice. The aim is to secure regularity of working and fuel economy with maximum output. The ore should be of uniform quality, or a uniform mixture of different ores should be used, with a suitable flux to produce the quality and composition of slag best suited to the process of smelting. Neither a very lean ore nor a very rich mixture of ores yields the best results. The more refractory the ore, the more finely should it be crushed, so as to be readily reducible. Two dangers present themselves here. A very fine ore offers great resistance to the ascending gases, and a greater quantity is carried into the flue as dust; therefore increased blast furnace pressure is necessary. It is important that the sizing, or separating of the ore, according to relative coarseness, should be carefully considered, and the charging of very fine and coarse ores together should be avoided if possible. The best plan is to separate it into two or three different sizes, and either smelt separately or smelt the coarser ones together. The fine ones can be best used after making into briquettes or agglutinating in some convenient way. If coarse and fine ores are smelted together they should be charged in in separate strata, and a strong blast used.

The Flux. What has been said of the ores applies in a great measure to the flux. It should be broken into pieces of uniform size and all dust avoided. The slag performs a twofold function — physical and chemical. Physically, it acts as a filter, purifying the globules of reduced iron as they pass through; and as a shield, protecting the metal from oxidation by the blast. Chemically, it absorbs sulphur, and assists in regulating the silicon content in the iron. The proper composition of the slag is very important. Alumina should be as low as possible, as, although it does not reduce the fusibility, it reduces the fluidity, which is a vital point in the blast furnace. A good slag should retain the solid form up to the melting point, and then become quite liquid, and not pass through a stage which causes sticking and hanging, and has a tendency to retain globules of iron.

Fuel. The fuel for the blast furnace may be raw coal, coke, anthracite, or charcoal. Of these the raw coal is seldom used alone—anthracite is generally too dear, and charcoal too expensive and too scarce. Coke is the best possible fuel for

modern blast furnaces. The fuel, it should be remembered, performs a physical and a chemical part. Physically, it preserves an open passage for the ascending gases, and for this reason should be hard, coarse, and uniform in size. Fine dust or breeze is very objectionable, as it blows over with the gas. Chemically, the fuel generates the requisite heat by semi-combustion with oxygen, and the carbonic oxide formed is a necessary reducing agent for the reduction of the oxide of iron. Coke should be highly porous, so as to offer the maximum surface to the oxygen of the blast. The most objectionable impurity in coke is sulphur, and phosphorus for special irons. The composition of the ash is almost as important as its quantity. The alumina should be low and the silica high.

Blast. The blast should be regular in quantity, and, as far as possible, constant in volume. A regular temperature is very important, since every 100 degrees of heat added is equal to 3 per cent. of the carbon burned at the twyers. Temperatures corresponding to a red heat are constantly used for heating the blast, but beyond this limit it is not advisable to go, although theoretically the limit is not reached until the fuel reduces the quantity of carbonic oxide to just that quantity required to reduce the ore. The introduction of the hot blast regenerative stove has enabled higher temperatures to be obtained, but it is subject to greater variability of temperature than the old pipe stove. The loss of temperature in an hour's blowing is from 200° C. to 300° C., and this is equivalent to an increase of 7½ per cent. of fuel burned in the hearth. This may be largely avoided by washing the gases and using larger or more numerous stoves. For noting uniformity of temperature a pyrometer is necessary, and an autographic record will show the temperature each minute if necessary.

The composition of the blast varies with the humidity of the atmosphere, and, as one pound of moisture requires 1·3 lb. of carbon to be burned at the twyers to replace the heat absorbed by the decomposition of this water, an enormous amount of heat is thus lost. This consideration has induced ironmasters to use desiccating plants for removing the moisture from the blast.

The Charge. The temperature and condition of the charge varies in different parts of the blast furnace. In the top portion the materials are warmed, and the oxide of iron is partially reduced. Lower down, the limestone flux is calcined, forming lime and carbon dioxide at a red heat. A little lower down still the carbon dioxide oxidises, the carbon of the fuel forming carbonic oxide at a bright red heat, and the reduced iron takes up carbon. This action is continued in the lower zones, in which also the oxides of silicon, phosphorus, etc., are reduced, and the silicon and phosphorus unite with the iron. In the bottom portion the furnace is at an intense white heat, the carburised impure iron is melted, as well as the slag, and both fall into the hearth. Carbonic oxide cannot completely reduce oxide of iron, so that other reducing agents are necessary, chiefly carbon. The reduction of oxide of iron takes place at comparatively low temperatures in the upper part of the furnace. In the middle portion the iron-reducing tendency is about balanced by the iron-oxidising tendency, while the carbon-depositing tendency is equalled by the carbon-oxidising tendency. In the lower portion the iron is reduced by carbon and carbonaceous bodies, such as potassium cyanide.

Changes. The changes occurring in cold-blast charcoal furnaces are somewhat different from those for hot-blast coke furnaces, for the charge will pass a considerable distance down the furnace before reduction begins. The ore appears to pass from ferric to magnetic oxide, then to ferrous oxide, before being reduced to the metallic state, so that, while in the coke furnace reduction takes place in the upper part by the action of carbonic oxide, the reduction in a charcoal furnace takes place in the middle of the furnace at a comparatively high temperature.

One of the most important factors in the proper working of a blast furnace is the suitable distribution of the charge, and this has been emphasised since the introduction of automatic charging apparatus. The tendency of the skip hoist to distribute coarse or fine ore unequally is a defect not yet overcome. The ideal charging apparatus should be under control so that the material may be distributed evenly over the entire area of the blast furnace. The cup and cone system falls far short as a distributor because of its narrow limitations and its inflexibility.

Waste Gases. The blast furnace gases are important factors in smelting, both inside and outside the furnace. Inside, they distribute the heat and reduce the ores to the metallic form, and the proper performance of their functions is determined by analysis. The gas temperature is also a valuable guide. A hot top indicates insufficient heat at the bottom, with the consequent production of inferior iron and bad slag. The waste gases from a blast furnace consist of carbonic oxide, carbon dioxide, and nitrogen, with small quantities of hydrogen and hydrocarbons. With furnaces using raw coal the gas is richest in hydrogen and hydrocarbons. In coke furnaces the volume of carbonic oxide is double that of carbon dioxide, and in charcoal furnaces the greater volume of carbon dioxide is found.

Waste gases have been chiefly used for heating boilers and hot-blast stoves. In some cases they are used for heating kilns, ovens, and general heating appliances. Blast furnace gases, after purifying, are now used for driving gas engines, and in this direction great economy may be effected in the production of cheap electricity for furnaces. The cleaning of the gases for engine work is indispensable. Cleaning should take place in three stages—a preliminary dry cleaning; a wet cleaning for use in stoves, boilers, kilns, and furnaces; and a special cleaning for power purposes by means of fans. Fewer and smaller stoves, less heating surface for boiler plant, diminished consumption of gas, less cleaning and

repairing will result from proper cleaning of the gases.

Slags. Blast furnace slags differ in colour and appearance according to the charge and the working conditions of the furnace. With excess of lime, the slag is white and fusible with difficulty. With a moderate amount of lime, the slag is grey, hard, and compact. When the furnace is making white iron the slag is dark in colour and very fluid, which makes it very corrosive on the furnace lining. It often contains much oxide of iron, and is termed a scouring slag. The slag is tapped from the furnace into bogies running on rails, and forms a mould of a truncated conical shape. In some works it is run through a bronze twyer on to a trough, and thence to small pans fixed on an endless chain which, by its revolution, delivers the slag into trucks. In some cases the slag is removed at intervals in side-tipping ladles.

The harder kinds of blast furnace slag, if not too glassy, are used for mending roads, for levelling waste lands, for building breakwaters, and for ballast. In the form of large blocks slag is used for road-making. It is used also for building purposes when suitable. For this intention it is moulded into bricks, which are kept at a strong heat for several hours in a closed space, in order to devitrify them and make them harder. Good bricks are made of granulated slag and lime. If not too acid, slag may be burnt in a state of powder with lime and yields a good hydraulic cement. The following are analyses of slags used for this purpose:

—	Bilbao.	Middlesbrough.	Saulnes, France.	Choindez, Switzerland.	Hartzburg, Germany.	Belgium.
Lime..	47·30	32·75	47·20	45·11	48·59	44·75
Silica	32·90	30·00	31·65	26·88	30·72	32·51
Alumina	13·25	28·00	17·00	24·12	16·10	13·91
Ferrous oxide ..	00·46	0·75	0·65	0·44	0·13	0·48
Magnesia	1·37	5·25	1·36	1·09	1·28	2·20
Calcium sulphide	3·42	1·90	—	1·86	2·16	4·90
Manganese oxide	1·13	0·60	0·85	0·50	--	0·60
Residue	0·17	0·75	1·29	—	0·42	0·65

Slag wool is made from blast furnace slag by blowing steam on to a thin stream of the slag in such a way that the steam encounters only half the stream. It is light and fireproof, and used for covering steam-pipes, etc.

The Blast Furnace. An English blast furnace of the old type was a massive stonework structure, circular in cross section, and the shaft approached in sectional elevation to that of two truncated cones joined at their bases. The lower cone was continued to the ground level or enlarged, forming the hearth, three sides being continued to the bottom, and the other left open for access. The interior was lined with firebricks. The dimensions varied from 9 to 10 ft. in diameter, and from 30 to 45 ft. high.

The blast furnace of to-day, compared with that of a century ago, is an efficient machine. Then, the consumption of fuel per ton of iron was often 10 tons; now, it is often less than 19 cwt. of coke. This has been mainly effected by the introduction of the hot blast and the utilisation of the waste gases for heating the blast. With some ores, cinders, etc., the consumption of coke reaches 30 cwt. per ton of iron. Approximately, 54 per cent. of the total heat is carried away in the waste gases, 6 per cent. in the slag, 3 per cent. in the iron, 6 per cent. in the water used, and 7 per cent. by radiation and conduction.

The modern blast furnace is an elongated barrel-shaped structure in interior vertical section, and generally circular in cross section. The height varies from 75 to 95 ft., the greatest width from 25 to 30 ft., and the maximum capacity of 50,000 cubic ft.

The body is formed of wrought-iron plates, half an inch thick, and riveted together. Within this is built the outer casing of ordinary masonry, the inside being lined with firebrick, about 18 in. thick, while in some cases between the two layers of brickwork is a small space filled with sand to allow for expansion and contraction. The body, or stack, is supported on a cast-iron ring, resting on pillars of the same material, and the lower part, from the top of the columns to the hearth, is also cased with iron and in some cases with water blocks. The hearth is independent of the masonry of the stack, and is built in after the stack is completed. It requires to be made of very refractory material of considerable thickness, having to withstand a very great heat in addition to the corrosive action of the molten slags.

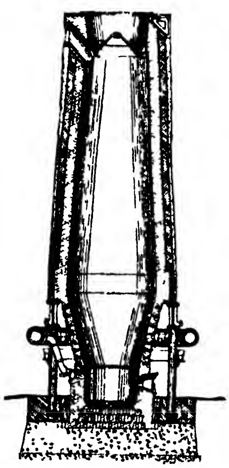
The hearth is perforated with six to eight holes for the introduction of the twyers, which convey the blast of air into the furnace. On the front or the working side the hearth was formerly extended, forming a rectangular cavity known as the fore-hearth, which was bounded in front by a very refractory stone, termed the *damstone*. The arch covering this was called the *tymp-arch*. The tymp was made either of a very refractory stone or of a hollow cast-iron box built in the masonry, and through this box a current of water constantly circulated to keep it cool.

Fig. 32 represents a modern American blast furnace. It is about 85 ft. high, 23 ft. wide at its greatest diameter, and of 11 ft. diameter in the hearth. The hearth is protected by water-cooled plates, and in the boshes are eight rows of bronze cooling plates, eight plates forming the circle, each plate having two watercourses. Cast-iron cooling plates are also placed between the twyers, the number of the latter being seven, each 6 in. in diameter. The cubical capacity is about 20,000 cubic ft. The charging bell is 12 ft. and the throat 15½ ft. in diameter. The volume of air blown in is 24,000 cubic ft. per minute. The temperature of the blast is 650° C., and the average pressure 8 lb. per square in. For flux 10 cwt. of limestone are required per ton of iron produced, and this amount is produced with 17 cwt. of coke. The output is about 2,000

tons per week. The following comparison between a typical English and a typical American furnace will show the different conditions in each case:

	Cleveland	Pittsburg
Cubical contents	25,500 ft.	18,200 ft.
Temperature of the blast..	704° C.	593° C.
Coke per ton of ore	19·99 cwt.	16 80 cwt.
Limestone	11 00 „	9·00 „
Ore	48 00 „	32 30 „
Weight of blast per ton of ore	87·15 „	71·20 „
Weight of gases	119·50 „	100·1 „
Temperature of gases	250° C	171° C
Tons of iron for 1,000 cubic ft. space of furnace per week	21 57	128 0
Slag per ton of iron	28 00 cwt	10 70 cwt
Calories produced per ton of iron	88 577	69·569

It will be observed by the above figures that the English furnace has much the greater capacity, the temperature of the blast is higher, and the calories of heat per ton of iron are more, therefore the fuel used per ton of ore is greater, the blast is hotter, the waste gases escape at a much higher temperature, the flux required and the slag produced are greater. The great reducing energy of the American furnace, with its high grade ore and rapid working, yields six times as much iron per cubic foot of space as the English furnace.



32. BLAST FURNACE

Pig Bed. This consists of a sand bed with a number of parallel grooves of a semi-cylindrical section, generally with their long axes towards the tap-hole, while the top ends of these furrows in each row are connected with a common channel running at right angles to them, and known as the sow, or feeder. These feeders themselves are put in connection with the main channel leading from the tap-hole. In some works the moulding is done by mechanical means, so that the pigs are of uniform size at equal distances apart, and are cast in groups of 30 or more. When cold, an overhead crane picks up each group and carries it to the pig breakers. Pig-iron casting machines are of various patterns, but have not yet come into general use.

Form and Dimensions of Blast Furnace. The horizontal section of the hearth varies with the pressure of the blast and the porosity of the materials employed. The height of the furnace must be limited when the fuel is friable (such as anthracite) or the ore fine, for if too compact the gases cannot circulate properly. Moreover, in a mass of different materials descending gradually, the effect of different densities becomes greater as the height of the furnace is greater. In some Cleveland furnaces the boshes are smaller than usual, while the greatest capacity is in the upper or reducing zone of the furnace. The inventors claim for this a lower fuel consumption and a greater regularity of working. The angle of the boshes as compared with the rest of the furnace varies in different districts; but the modern tendency seems to be in the direction of boshes low down in the furnace and at an angle of about 75°. The section of most furnaces is round, which economises heat and causes it to be more uniformly distributed. The hearth is circular in section. The greater the diameter of the hearth and the greater the vertical distance between the slag notch and the twyers, the larger is the output. The tap-hole should be on a line midway between the twyers, and the same remark applies to the slag notch.

Twyers. The twyers are made with a double casing that water may flow between. In some twyers the cooling water in the form of spray is driven from the end of a perforated pipe against the port of the twyer.

The Scotch twyer consists of a spiral wrought-iron tube enclosed in a cast-iron casing, and water circulates through the coil to keep it cool. The number of twyers varies according to the nature of the ore and fuel used. Excessive blast consumes too much fuel, cools the slag, and impedes the working. The cutting action of the blast on the lining is reduced by allowing the twyers to overhang, but this at the same time reduces the melting action of the hearth.

The blast is heated by causing it to pass through hot stoves, of which there are two chief kinds—cast-iron stoves, containing pipes heated by solid fuel, and stoves of refractory brickwork, constructed on the regenerative principle. Two principal forms of the latter are employed, invented by Cowper and Whitwell respectively.

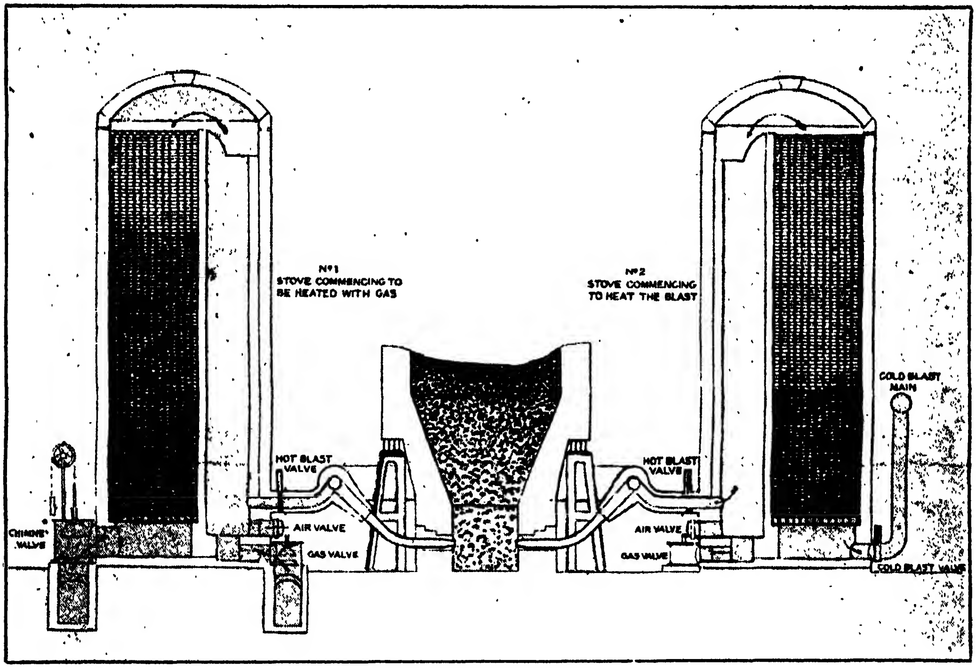
Stoves. The Cowper stove [33] is a circular, wrought-iron tower, 60 ft. high and 28 ft. in diameter, closed with a high dome-shaped roof and lined internally with firebrick constructed on the regenerative principle. About two-thirds of the interior is lined with a checker work of brick for absorbing the heat obtained from the combustion of the waste gases from the blast furnace. A large vertical flame flue receives the gases, in which they are ignited. The flame passes downwards through the checker brickwork and makes it red hot. When this has continued a sufficiently long time the air, gas, and chimney valves are closed and the cold blast admitted in the opposite direction, when it takes up the heat from the brickwork and passes on to the blast furnace through the hot-blast valve as shown in 33. It is necessary to have two stoves for each furnace, so that one may absorb the heat from the burning gases, while the other is heating the blast. The bricks are of spical shape, and when they are placed together form hexagonal passages with walls 2 in. thick. As compared with the pipe stoves

the Cowper stove gives a much higher temperature, and has led to an increased yield from similar furnaces of 20 per cent.; the fuel consumption is at the same time lessened. One disadvantage of regenerative brickwork stoves is the liability to become choked with dust, especially when finely-divided ores are being smelted; this necessitates occasional cleaning, and for this purpose Mr. C. Wood, of Middlesbrough, employs a brass cannon, which is charged with powder, run into the stove, and fired. The explosion displaces the dust, which is allowed to settle and then removed. Another method depends on the use of release valves which allow of the instantaneous discharge of the imprisoned air. A cloud of dust is immediately discharged and shot up into the air.

The Whitwell Stove. The Whitwell stove is cylindrical, with a domed top and lined with firebrick, but the internal arrangement is different from that of the Cowper stove. The regenerators consist of a number of firebrick passages made of 5-in. brickwork. This brickwork contains a main combustion flue for the burning of the waste gases, and air is admitted by special feed passages. The hot and partially-burned gases pass repeatedly up and down through the passages, giving up their heat to the brickwork. The reversals are much the same as in the Cowper stove, and two stoves are required to one blast furnace. Many modifications of the above are in use in different districts, some of which combine the advantages of both systems.

The Ford - Moncur Stove. The Ford-Moncur stove is one that has met with considerable favour of late years. The bricks are dome-shaped so as to prevent dust lodging on them. The stove is also divided into four different parts by vertical partitions, so that when it is desired to clean out the dust the blast may be turned on to each partition separately.

Lifts. The materials are brought to the top of the blast furnace by lifts of various kinds. The inclined plane consists of a railway on which runs a triangular platform with two unequal pairs of wheels. The power is supplied by a steam engine, working a winding drum, around which passes a wire rope or a flat-linked chain. Another form is the colliery lift similar to that used in a coal-mine. A pneumatic lift is often used, and consists of a cast-iron ram, working in a long cylinder rising the whole height of the furnace. From this pass wire ropes over large pulleys to a lifting table, which contains the loaded trucks or barrows.



33. THE COWPER STOVE

Continued

CHILDREN'S CLOTHING
continued from page 4357

DRESS FOR GIRLS

Frocks: Drafting, Cutting, and Making. A Princess Petticoat and a Circular Skirt. Overalls. Hints on Lengthening

By AZÉLINE LEWIS

FROM four to six years old and onwards, girls' clothing assumes a definite character, though simplicity should always be the keynote of children's fashions.

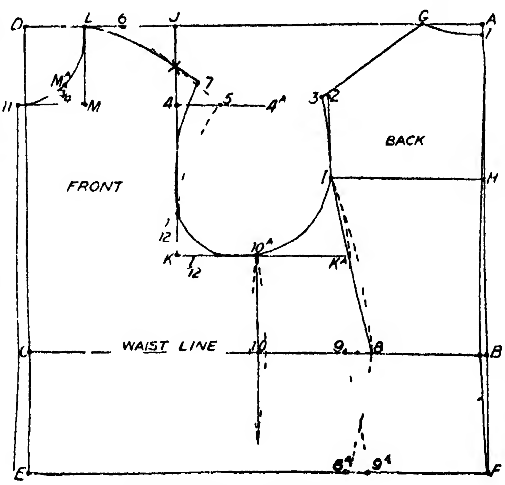
With respect to underwear, the patterns of combinations already given will be a suitable shape up to the age mentioned, unless chemise and drawers be preferred, for which draftings are given. The nightdress pattern also will be quite right if cut somewhat larger and longer. It can be made to fasten at the side if preferred. [For larger sizes, see UNDERCLOTHING.]

The princess form of petticoat is preferable to the banded affair, unless this be buttoned on to a plain under bodice, so that the weight rests on the shoulders. If the latter be preferred, the skirt portion should be gored somewhat, so as not to add to the bulk at the waist. For girls in the early 'teens, inclined to be stout, the princess form of petticoat is best. In this case it is better made with a deep frill, cut either shaped or straight.

Frocks. The plain shoulder yoke and smocked style should not be worn after eight years of age—and not then if the child is inclined to be tall and thin—certainly not by girls of 10 and 12 years of age, as we have seen, unless secured to the waist by a sash or loose belt. The Empire yoke, of course, can be worn by girls of any age, but it is not particularly becoming to a stout child.

Foundation Bodice. As was shown in our Dressmaking course, all garments are modelled or built upon a skirt and bodice pattern, so 46 gives a drafting suitable for a child of six to eight years of age. This follows on the lines of that in DRESSMAKING, with the necessary exceptions, and can be adapted to any size. Chest measurement, 25 in.; back length, 8 in. This last measure, however, is a very elastic one, as the waist is not clearly defined in so young a child and the drafting shows a short-waisted affair, which will do for the Victorian coat.

A to D, chest measurement; B to A and C to D, length of back plus ½ in. for neck curve; D to E and A to F, entire length. The waist-line can be altered to any depth without affecting or interfering with the drafting in any way, the only alteration needed being that darts or side pieces—if made—must be carried down to the waist line. A to H and H to I, one-third of chest measure; A to G, one sixth of neck measure less ¼ in. for curve. A to I, ¼ in. Curve from G to I for back neck. A to J, two thirds of chest measure; J to K, one-half of the same less ½ in.



46 BODICE DRAFTING.

Draw line from K at right angles towards back (this is merely as a guide for armhole); mark Ka.

I to 2, one sixth of half chest measure (this, however, varies with fashion, and may be less or more according to taste). 2 to 3, ¼ in. Draw a line from 3 to G for back shoulder and curve from 3 to I for back armhole.

J to 4 is same length as from I to 2. Draw a line at right angles to the right. Mark centre of J–4, then measure back shoulder, and draw same length for front from line 4 to line D A, with centre on the cross marking centre, as shown by broken line. Make dots one twelfth of chest measure on each side of angle K; curve from 5 to I, passing through dots on each side of angle K.

B to 8, 3 in. Draw a line from I to 8 and curve ¼ in. to right of this line for back.

Advance 7 one twelfth of an inch towards D, make L, and draw shoulder as shown by firm line.

8 to 9 is 1 in.; curve from I to these points; 8 to 10 is 3 in.; draw line to armhole and make 10*a*, then curve ½ in. either side of this at waist, for under-arm.

These lines are shown by a broken line, as they are quite optional, shaping at these portions not being always necessary. They should not be cut, but just marked with the tracing-wheel if made to the waist only.

Now measure pattern and add on what may have been taken in by the side-piece to make the chest measure correct, and mark 11. Draw L to M one-sixth of chest measure, then from M to 11. From M to M*a* is ¾ in.; curve from L to 11 for neck.

For the lower portion, make a point midway between 8 and 9, also one immediately below

on line E to F, and draw lines 8*a* and 9*a* the same distance—*i e.*, ½ in —to right and left

Extend lines on either side of 10 2½ in below waist, and curve from waist to point of these Trace round the pattern and cut out, following the firm line for the front shoulder and arm holes

This method can be used for any size up to 12 years of age After this period one or two darts may be required, and the various draftings already given in DRESSMAKING and TAILORING can be followed or modified according to requirement

With the aid of this pattern any kind of bodice can be made The method of obtaining a yoke of any shape has been fully explained in DRESSMAKING [see 39 to 43, page 479] If one of the Empire style be preferred cut to the depth required below the armhole, whilst if the long-waisted French bodice be the model, simply extend the lower portion as much below the waist as may be needed sloping it out slightly from armhole to lower edge It should not, however, extend too far, as this impedes the movements of the child If the bodice be gathered allow for the necessary amount in front or at the shoulders, according to the design If pleated model the pleatings on the pattern drafted, which as already remarked forms the foundation for all kinds of styles The neck portion may also be cut round or pointed or square, or any shape preferred

As to the skirt this can be obtained from the model shown in GIRLS TAILORING [p 2469] where full directions are given for drafting a circular skirt adaptable to any size and shape See also drafting for skirt of Victorian Coat [50], which will be equally suitable

The skirt portion of an Empire yoke may be either circular or straight pleated or gathered as preferred The frock part of one with a shoulder yoke, or saddle, should be sloped at the under arm seams, and also requires rounding slightly at the armhole The lower edge should be cut a little—a very little—shorter at the sides, as it always has a tendency to drop here

To cut an American blouse from the drafting just given, slope the fronts out half an inch at E; cut through 10 and 10*a* and slope out the sides each 1 in, as shown by the double line, when, of course, no side piece would be required, and the centre back must be placed to a fold

For the sleeve, any of the draftings already given can be followed according to fashion The drafting of a collar has been shown in several of the previous diagrams

Fig 47 gives a few examples of garments suited to girls of the ages mentioned, but from this period and onwards the various fashions may be consulted so these designs are merely given as models which may form the foundations of an endless variety of other styles, with slight alterations and additions These, however we think will readily occur to the worker who has followed either or all, of the previous courses

47 A GIRL'S WARDROBE

Chemise and drawers are not illustrated, as those already given for children of one to four years of age can quite easily be enlarged

The same remark, too will apply to the combinations

We will now describe the garments sketched

(*a*) A princess frock

(*b*) Here we have the divided skirt already mentioned in the garments for the toddler The method of obtaining this pattern is indicated in the drafting of the first knickers, by a broken line, so is not given again The material and trimming are, of course a matter of taste but for small children this is a much better shape for the flannel petticoat than the ordinary skirt form In this case it would be better without the frill and the edges finished off with a festooned hem The fastening is at the back the closing being accomplished by means of several buttons and buttonholes

(*c*) A Russian frock

(*d*) A plain overall or frock, cut all in one piece

(*e*) A German pinafore The shape of this quaint little model hailing from the Fatherland, is explained by the back view It is cut all in one piece, and fastens on the shoulder

(*f*) Long waisted French petticoat, with two circular frills for the skirt portion This shape sets out the frock very prettily at the lower edge Directions for cutting circular and shaped frills

have already been given in DRESSMAKING, whilst those for the shaped skirt part of the Victorian coat can also be adapted to the size required. This style of petticoat is better suited to cambric or longcloth for white summer ones.

(g) The long-waisted style, known as the French frock.

(h) A sailor style for either boy or girl. This is termed a quartermaster frock, and is cut exactly the same as the man-o'-war style [page 4355], the only difference being that the fronts are left open and faced.

(i) The flannel vest or bodice to be worn with this style of frock, which is made of fine white flannel or cloth.

(j) A princess petticoat.

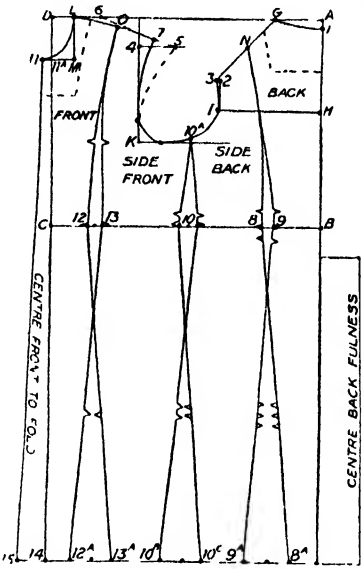
(k) Reefer coat and skirt costume.

(l) Red Riding Hood cloak.

(m) A Victorian coat.

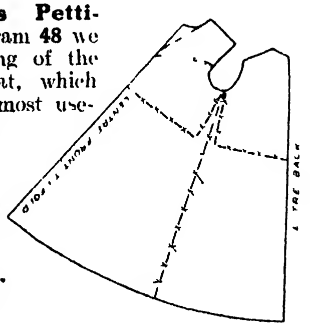
(n) Overall frock with yoke and box-pleated front, modelled as (i).

The making of a coat with step-collar and Norfolk coat, also of a girl's sacque coat, have all been fully explained in BOYS' AND GIRLS' TAILORING, and these styles, with slight modifications of size, style and length, are all suited to girls' outdoor wear, the loose Norfolk coat being especially neat and becoming to a young girl.



48. PRINCESS PETTICOAT

A Princess Petticoat. In Diagram 48 we have the drafting of the princess petticoat, which will be found a most useful one. This is drafted to a 28-in. chest measurement. The working of the upper portion is exactly the same as 46, allowing for the difference of measures, with the exception of 1 to 2, which is $1\frac{1}{2}$ in., to allow for the longer shoulder. 8 and 8a, 9 and 9a are omitted. Make 8 $2\frac{1}{2}$ in. from B, without sloping this in at centre-back. Make N midway between G and 3, and curve slightly from N to 8; make a dot $\frac{1}{2}$ in to right of 8, and curve from here to meet line N at width of back line. Now make 12, $2\frac{1}{2}$ in. from C on waist line; make O midway between L and 7, curve slightly from O to 12. Make a point $\frac{3}{4}$ in. to right on waist line, curve up from this to meet line O.



49 OVERALL

Curve from 10 to 10a as in 46.

Extend from 11a to length required, in this case 30 in.; make 14, then make a point 1 in. to left of this mark, 15, and slope from this dot to 11, to give a little extra width for centre-front. Make a dot $2\frac{1}{2}$ in. to right of 14, then make another 1 in. to right and left of this, and draw a line from 12 and 13 to these dots, as shown at 12a and 13a. Make a dot level with 10 the same distance as from C to 13; make dots $1\frac{1}{2}$ in. to right and left, and draw a line from waist to meet these, as at 10b and 10c. Treat line N to 8 and 9 the same for the side of back and centre-back.

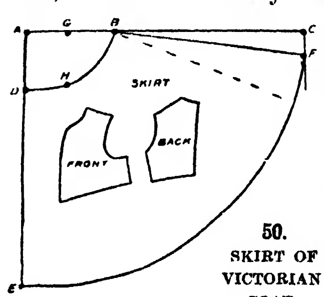
Two inches below B make a dot; then add on 2 or more inches for back fulness to the bottom, which make the same length as from 9 and 10. Trace the pattern round carefully and cut out, placing the various notches as shown, as these are a guide for putting together.

This drafting will do for the princess frock shown at A in 47, the only alteration being needed at the side and back, which are gathered on to the waist in the ordinary skirt fashion.

For this style the back of the bodice is cut slightly below waist at back, the skirt portion consisting of straight or very slightly gored widths, being made as full as taste may dictate. It is joined on to the side seam and the waist part of back of bodice, whilst the bodice trimming is carried over the shoulder to the skirt at back waist.

By altering the position of the side seam, as from N and O, to nearer the shoulder, the same drafting will do for the Russian frock marked at (c) in the same diagram. In this case the front portion is folded over towards the sleeve to form a pleat, which is stitched down quite flat. This frock fastens at the left side under the fold, so a narrow left-side front will be required.

It would also form a corselet or suspender frock, all that is necessary being to cut it to the approved height above the waist line. Should it be preferred with inverted pleats at the seams, the required amount for these can be easily added on at each seam, exactly as shown for the centre-back. Such an arrangement always looks better if the pleats slope upwards, in height, from the front, the highest being at the centre-back.

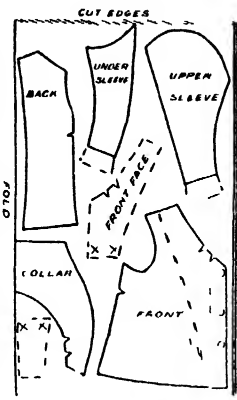


50. SKIRT OF VICTORIAN COAT

This design would make a very pretty little

frock, whilst the pleats could either be inverted, or box-pleated outside the seams, where they could be mitred off at the tops or finished off in various ways. Care must, however, be taken to keep them perfectly even, and not let them drop at the sides.

No. 49 illustrates the overall depicted at (*d*) in the sketch under consideration, which is easily obtained from the bodice drafting of 46, as the broken lines show, or the princess frock drafting of 48, by omitting the side seams. It will form the foundation of (*n*), and many others. This can be cut all in one piece, or with an underarm seam, as preferred. The broken line and crosses show the portion not to be cut. If made quite plain with the V-shaped opening, cut as shown by the broken line. If with the pointed yoke as at (*d*), cut this as indicated by the double broken line, and model the box pleat at the lower portion as already mentioned for the tunic suit and girl's skirt mentioned in GIRLS' TAILORING. If made V-shaped at back and front of neck, and pleated instead of quite plain, this makes a very pretty frock to be worn over lace vests.



51. REEFER COAT

To make a perfectly plain overall or frock, as at (*d*), 2½ yd. of 27 in. goods are required.

Circular Skirt. No. 50 shows the drafting of the circular skirt for the Victorian or Empire coat, the bodice being obtained from 46.

A to B, half of waist measure less 1 in; A to D, a quarter of same; D to E, skirt length, in this case 24 in., but it may be made any length desired. B to C, same length as from D to E; C to F, 3 in. Extend D to E, and draw line from B to F; G, midway between A and B; G to H, ¼ of waist measure (6 in.). Curve from B through H to D, measure from this the length of skirt; also midway between make marks for outer circle and curve from F to E.

If a pleated skirt be desired, the foundation need not be quite so full, and may be decreased as shown by the broken line. Upon this the pleated portion can be modelled. The sleeve can be obtained from the previous drafts.

For the making of the coat, see TAILORING—Ladies' Empire Coat [page 2328]—for which the instructions there given can be followed. If of fairly thick cloth, the bodice only need be lined, when the seams and edges should be neatened by binding.

The required quantities for this coat with circular skirt would be 2½ yd. of 44-in. goods, 1 yd. of Italian cloth for bodice lining, and a small quantity of fine French canvas for interlining.

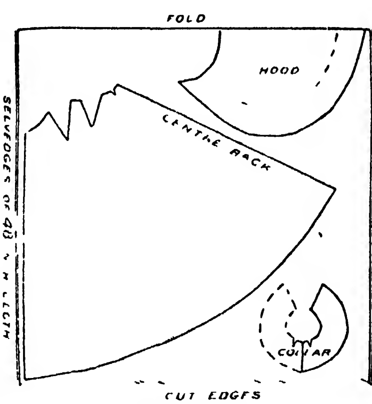
For children, separate collars are the best kind of neck finish, as they can be removed and laundered.

Number 51 shows the method of cutting out the reefer coat from 48-in. cloth, of which 1¼ yd. should be sufficient. The drafting and making of this jacket are similar to that of the sacque in GIRLS' TAILORING, to which we must refer the worker for instructions on this point. The collar can be easily altered to the ordinary sailor style if wished by sloping it off to the front. The facing will require joining, as shown by the crosses, the seams of which must be carefully pressed.

A cloak of the Red Riding Hood order forms a most welcome addition to a small girl's wardrobe, and, indeed, is useful at almost any age [52].

The cloak shown is made with a collar and hood, and is fitted to the shoulder by two darts. If made without the latter, it will need to be almost circular, and this adds the fulness at the lower part, which is therefore apt to fly about too much for the comfort and warmth of the small wearer; for this reason the shape shown is recommended.

This cloak will require 2½ yd. of 44-in material, and in the making care will have to be taken to keep the edges thin and the corner of the cape and collar quite sharp. When making the latter, be careful to ease the upper portion slightly 1 in. from each corner, as mentioned in Pocket-flaps [see BOYS' TAILORING, page 1291], when putting on, so as to get this to set over and not curl up. The upper edge should also come slightly over the under one, as in making boys' coats.



52 CLOAK

Girl's French Frock. For the girl's French frock, cut the bodice lining according to the drafting of 46 or 48, according to the age and size of the child, making this the length required. Model one side of front as sketched, making it cross over a little beyond the centre. If the worker is not very expert, she had better do this in paper. Cut it out carefully, then fold the material and cut two pieces exactly alike, marking the pleats to keep them even, and placing the crossover edges to the selvedges. This is very important, as, if placed on the bias, the fronts will stretch and soon get out of shape. The backs are pleated from the shoulder and neck, and do not cross over or require a vest of white as in the front.

The skirt is merely a straight length of material 12 in. to 14 in. or 16 in. deep, according to the age and requirements, but, as already remarked, should not extend below the knees. It may, however, be kilted instead of gathered, which has an extremely good effect. The directions already given for making the kilt can be followed if this style of skirt is preferred.

When making this frock, mark the turnings very carefully, then tuck the vest and tack in position. Hem the crossover edges of fronts, press well, and arrange these as sketched on the lining foundation, right crossing over left; gather lower edge and tack to foundation, allowing it to pouch somewhat. Turn in the edges of foundation back to the marks, machine-stitch, and make button-holes on the right side 1½ in. apart, and sew buttons on left to correspond.

Turn in the edges of material back to form an inch-wide hem, and machine this next at the edge. Arrange and tack material backs on foundation, the edges overlapping a little; tack fronts and backs together at shoulder and underarm seams, machine-stitch, open, oversew, and press. Then sew six or eight small hooks backwards on the inside of hem at centre-back on the stitching, and make silk loops on the left side to correspond. Gather lower edges, arrange, and pin in position on lower edge of foundation, and tack to this. Tack the collar and secure this to neck. Then place right hem of foundation over the left hem; stitch firmly together; arrange the right and left material backs to correspond, and secure together an inch or so above this to prevent gaping open when on.

Join the skirt portions required, open and press seams, turn up lower edge and make a hem from 1 in. to 2 in. wide. Mark centre of back and front, gather upper edges, using one thread for each division; place centres of front and back to those of bodice, being careful to have no seam in centre-front. Draw up gathers to fit bodice, arrange so that the fulness is graduated off to the back, pin and sew in place, then neaten with a strip of material or binding, which should be hemmed to foundation and fastened off securely at back.

The Sleeves. Join the sleeves by means of a French seam (unless the material be too thick), and gather the lower edges. Now join up the cuff portions, open and press seams, fold in half along the centre of cuff, then turn in upper edges to face. Draw up cuff edges of sleeve to fit, insert between them, stitch together and fasten off the ends neatly. Make the other sleeve and cuff to correspond, then gather the upper part, ascertain position of front seam, arrange in armhole, sew them firmly in place and oversew or bind neatly. Sew in the other sleeve to correspond.

Finish off waist part with folded belt.

This frock will take 2¾ yd. of 44-in. material, 1¼ yd. of lining, and ½ yd. of silk for vest and collar. It can, of course, be varied in many ways, and made with a square or pointed yoke, elbow or puff sleeves; also with open neck, which looks very pretty for small children's summer wear.

Hints on Lengthening. With regard to lengthening, the last-named style is one of great possibilities in this most important detail.

Sleeves are generally more difficult to deal with in this respect. The simplest way, however, is to make these either of the bishop or puff order, a little longer than the required length, when a few tiny horizontal tucks at the elbow will serve for ornament at first and length later on. If on a foundation a tuck should be run in this, just above the elbow.

For petticoats, the bodice part can always be made a little longer than is necessary and a tuck put in this, which is then easily let down when necessary.

For frocks, the skirt part can either be secured an inch or more above the lower edges of bodice, or a tuck made in the foundation, to be let down as needed. In other cases wide hems or tucks should be made, whilst the bodice should always allow for expansion and be an easy fit.

One point of importance should not be forgotten. It is important that the skirt should hang perfectly evenly all round, and, if anything, a trifle shorter at the back than the front, rather than have the slightest suspicion of a "dip" there. This detail, apparently a trifling one, is frequently overlooked, and makes all the difference between a well-dressed child and a dowdy one.

For a child's bathing gown, the combination pattern given will be suitable, whilst for a later period it is also better to have a combined under-garment and a separate skirt portion, both for bathing and gymnastic purposes. [See also UNDERCLOTHING.] Small girls, it may be mentioned, are often clad in a sailor suit for gymnastic exercises.

At about twelve years of age begins the awkward period of a girl's attire, when, however, the varying fashions may be more or less consulted and adapted. It would be impossible to deal with all these, but, as has been already remarked, simplicity should always be the guiding principle, with a certain regard for the type and characteristics of the young girl herself, who is usually gauche and awkward enough at the "between age" without having these peculiarities accentuated by her clothing.

A full frock with an empire yoke outlined with a thick-folded belt with large bow and long ends, and fichu-like drapery at the neck, would not rouse enthusiasm on a stout and short-necked girl, but worn by her slim sister the result would be charming. In the first case, lines of trimming, or folds, arranged to give length and decrease the apparent width should be selected. Injudicious or unbecoming attire has a very subtle effect on the character, particularly at this susceptible period, and shyness and self-consciousness are often increased thereby. Therefore, we repeat, let children's clothing be well chosen, but, above all, let it be very simple.

☛ CHILDREN'S CLOTHING *concluded; followed by* MILLINERY

PARALLEL LINES

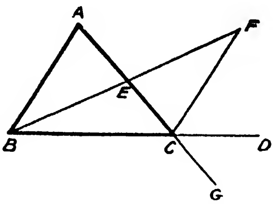
Theory of Parallel Straight Lines. The Value of the Angles of a Triangle, and of those of any Rectilineal Figure

continued from page 4331

By HERBERT J. ALLPORT, M.A.

Proposition 10. Theorem

If one side of a triangle is produced, the exterior angle is greater than either of the interior opposite angles.



Let ABC be a $\triangle$ in which BC is produced to D.

It is required to prove that the $\angle$ACD is greater than either of the $\angle$s ABC, BAC.

Construction. Bisect AC at E. Join BE and produce BE to F, making EF = BE. Join CF.

Proof. In the $\triangle$s BAE, FCE,

AE = CE, BE = FE

$\angle$AEB = vertically opposite $\angle$CEF (*Prop.* 3).

$\therefore$ $\triangle$s are equal in all respects (*Prop.* 4).

$\therefore$ $\angle$BAE = $\angle$FCE.

But $\angle$ACD is > $\angle$FCE.

$\therefore$ $\angle$ACD is > $\angle$BAE,

i.e., > $\angle$BAC.

In the same way, by producing AC to G and joining A to the middle point of BC, we can prove that $\angle$BCG is > $\angle$ABC. But $\angle$BCG = $\angle$ACD (*Prop.* 3).

$\therefore$ $\angle$ACD is > $\angle$ABC.

Corollary 1. *Any two angles of a triangle are together less than two right angles.*

For $\angle$ABC has been proved < $\angle$ACD.

$\therefore$ $\angle$s ABC, ACB are together less than $\angle$s ACD, ACB, *i.e.*, < two right angles (*Prop* 1).

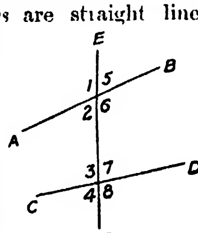
Corollary 2. *Every triangle must have at least two acute angles.*

For, if it has one angle equal to, or greater than, a right angle, then, by Cor. 1, each of the other angles must be less than a right angle.

Hence, a triangle is only called acute angled when it has *all* its angles acute.

Parallel Lines

1. *Parallel straight lines* are straight lines which *lie in the same plane* and which do not meet however far they are produced in either direction.



2. Let the two straight lines, AB, CD be cut by a third straight line EF. Then, of the eight angles formed,

1, 4, 5, 8 are called *exterior* $\angle$s.
2, 3, 6, 7 are called *interior* $\angle$s.
2 and 7 are called *alternate* $\angle$s.
3 and 6 are also alternate $\angle$s.

If we are referring to any one of the exterior angles, say 5, then 7 is called the *interior opposite angle on the same side of EF.*

3. *Playfair's Axiom. Two straight lines which intersect cannot both be parallel to a third straight line.*

Proposition 11. Theorem

If a straight line cuts two other straight lines and makes, either

(i.) *the alternate angles equal;*

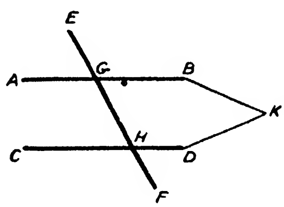
or (ii.) *the exterior angle equal to the interior opposite angle on the same side of the cutting line;*

or (iii.) *the two interior angles on the same side of the cutting line together equal to two right angles,*

then, in each case, the two straight lines are parallel.

Let the straight line EF cut the two straight lines AB, CD, at the points G and H.

(i.) Let the $\angle$AGH = the alternate $\angle$GHD.



It is required to prove that AB is $\parallel$ to CD.

Proof. If AB and CD are not $\parallel$, they will meet when produced, either in the direction of A and C, or in the direction of B and D.

Suppose they meet when produced towards B and D, in the point K.

Then, GHK is a triangle, with the side KG produced to A.

$\therefore$ The exterior $\angle$ of the triangle, $\angle$AGH, is > the interior opposite $\angle$GHD (*Prop.* 10).

But $\angle$AGH is given *equal* to $\angle$GHD, and they cannot be both equal and unequal.

$\therefore$ AB and CD cannot meet when produced.

$\therefore$ AB and CD are parallel.

(ii.) Let the exterior $\angle$EGB = the interior opposite $\angle$GHD.

It is required to prove that AB is $\parallel$ to CD.

Proof. Since $\angle$EGB = $\angle$GHD (*Hyp.*),

and $\angle$EGB = $\angle$AGH (*Prop.* 3).

$\therefore$ $\angle$AGH = $\angle$GHD.

But these are alternate $\angle$s.

$\therefore$ by (i.), AB and CD are $\parallel$.

(iii.) Let the interior $\angle$s BGH, GHD, together equal two right angles.

It is required to prove that AB is $\parallel$ to CD.

Proof.

$\angle$BGH + $\angle$GHD = 2 right $\angle$s (*Hyp.*),

and $\angle$BGH + $\angle$AGH = 2 right $\angle$s (*Prop* 1).

$\therefore$ $\angle$BGH + $\angle$GHD = $\angle$BGH + $\angle$AGH.

$\therefore$ taking away the $\angle$BGH from each of these equals, we have

$$\angle GHD = \angle AGH.$$

But these are alternate $\angle$s.

$\therefore$ by (i.), AB and CD are $\parallel$.

Proposition 12. Theorem

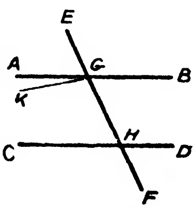
If a straight line cuts two parallel straight lines, it makes,

(i.) *The alternate angles equal.*

(ii.) *The exterior angle equal to the interior opposite angle on the same side of the cutting line.*

(iii.) *The two interior angles on the same side of the cutting line together equal to two right angles.*

Let the straight line EF cut the two parallel straight lines AB, CD at the points G and H.



It is required to prove that

(i.) $\angle$AGH = alternate $\angle$GHD.

(ii.) $\angle$EGB = interior opposite $\angle$GHD.

(iii.) $\angle$BGH + $\angle$GHD = 2 right $\angle$s.

Proof. (i.) If the $\angle$AGH is not equal to $\angle$GHD, suppose the $\angle$KGH is equal to $\angle$GHD and alternate to it. Then

KG is $\parallel$ to CD (*Prop.* 11).

But AB is $\parallel$ to CD (*Hyp.*).

$\therefore$ there are two intersecting straight lines AB, KG, which are both $\parallel$ to CD. But, by Playfair's Axiom, this is impossible.

$\therefore$ $\angle$AGH is not unequal to $\angle$GHD, *i.e.*, $\angle$AGH = $\angle$GHD.

(ii.) Since $\angle$EGB = $\angle$AGH (*Prop.* 3), and $\angle$AGH = $\angle$GHD (By i.).

$\therefore$ $\angle$EGB = $\angle$GHD.

(iii.) $\angle$AGH = $\angle$GHD. Add to each the $\angle$BGH.

$\therefore$ $\angle$AGH + $\angle$BGH = $\angle$GHD + $\angle$BGH.

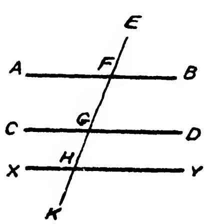
But $\angle$AGH + $\angle$BGH = 2 right $\angle$s. (*Prop.* 1).

$\therefore$ $\angle$BGH + $\angle$GHD = 2 right $\angle$s.

Proposition 13. Theorem

Straight lines which are parallel to the same straight line are parallel to one another.

Let AB, CD, each be $\parallel$ to XY.



It is required to prove that AB is $\parallel$ to CD.

Draw a straight line EK cutting AB, CD, XY, at the points F, G, H.

Then, since AB is $\parallel$ to XY, and EK meets them

$\therefore$ $\angle$AFH = alternate $\angle$FHY;

and, since CD is $\parallel$ to XY and EK meets them

$\therefore$ $\angle$FGD = interior opposite $\angle$FHY.

$\therefore$ $\angle$AFH = $\angle$FGD.

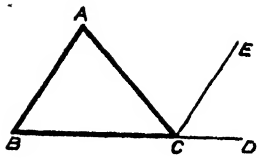
But these are alternate $\angle$s.

$\therefore$ AB is $\parallel$ to CD (*Prop.* 11).

Proposition 14. Theorem

The three angles of a triangle are together equal to two right angles.

Let ABC be a Δ.



It is required to prove that

$\angle$ABC + $\angle$BCA + $\angle$CAB = 2 right $\angle$s.

Produce BC to any point D, and let CE be the straight line through C which is $\parallel$ to BA.

Proof. Since BA and CE are $\parallel$, and AC meets them

$\therefore$ $\angle$ACE = alternate $\angle$BAC;

and, since BA and CE are $\parallel$ and BD meets them

$\therefore$ $\angle$ECD = interior opposite $\angle$ABC.

$\therefore$ $\angle$ACE + $\angle$ECD = $\angle$BAC + $\angle$ABC,

i.e., $\angle$ACD = $\angle$BAC + $\angle$ABC.

To each of these equals add $\angle$BCA.

Then

$\angle$ACD + $\angle$BCA = $\angle$BAC + $\angle$ABC + $\angle$BCA.

But

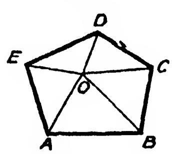
$\angle$ACD + $\angle$BCA = 2 right $\angle$s (*Prop.* 1).

$\therefore$ $\angle$ABC + $\angle$BCA + $\angle$CAB = 2 right $\angle$s.

NOTE. In the course of the proof we have shown that *if one side of a triangle be produced, the exterior angle is equal to the sum of the two interior opposite angles.*

Corollary 1. All the interior angles of any rectilineal figure, together with four right angles, are equal to twice as many right angles as the figure has sides.

Let ABCDE be a rectilineal figure.



Take any point O within the figure, and join O to each of the angular points. The figure is thus divided into as many Δs as it has sides.

Now, the three $\angle$s of each Δ = 2 right $\angle$s.

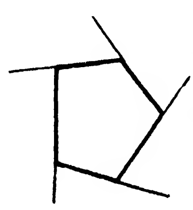
$\therefore$ the $\angle$s of all the Δs = twice as many right $\angle$s as there are Δs.

= twice as many right $\angle$s as the figure has sides.

But the $\angle$s of the Δs make up the $\angle$s of the figure together with the $\angle$s at O, and the $\angle$s at O make four right $\angle$s (*Prop.* 1. *Cor.*).

$\therefore$ $\angle$s of the figure + four right $\angle$s = twice as many right $\angle$s as the figure has sides.

Corollary 2. If the sides of a rectilineal figure which has no re-entrant angle (i.e., no angle greater than two right angles) are produced in order, the exterior angles so formed are together equal to four right angles.



The interior $\angle$ + the exterior $\angle$ at any angular point = two right $\angle$s.

$\therefore$ all the interior $\angle$s + all the exterior $\angle$s = twice as many right $\angle$s as the figure has angles, *i.e.*, as the figure has sides.

But, the interior $\angle$s + four right $\angle$s = twice as many right $\angle$s as the figure has sides (*Cor.* 1).

$\therefore$ the interior $\angle$s + the exterior $\angle$s = the interior $\angle$s + four right $\angle$s.

$\therefore$ the exterior $\angle$s = four right $\angle$s.

Continued

BORING, SCREWING & SAWING TOOLS

Different Classes of Bits. Taps and Dies and their Principles. Saws. Forms of Saw Teeth and Set of Saws

By JOSEPH G. HORNER

Woodworkers' Boring Tools. The differences between these and the drills and allied tools used by metalworkers are, as in other tools, chiefly those due to cutting angle, which again is governed by the difference in the softer and harder character of the materials operated on. The woodworkers' boring tools have a small tool angle; the angle of front rake, or that of the cutting face often approximates very closely to that of the face of the material being cut, and the angle of top rake is low, permitting of the free escape of the shavings. These points are seen in the numerous bits and auger bits. The term *bits*, with suitable prefixes, denotes a large and varied group of useful tools, some being seen in 38 to 42; but though these bits possess in common the features just stated, their variations call for some further explanation.

Two Classes of Bits. There are two kinds of holes required in timber—one in which location to a precise centre is not essential, the other in which it is. The ordinary shell bit [38], A, spoon bit, B, nose bit, C, and augers [39], A, do not bore accurately, because they possess no centring tit. The gimlets, and gimlet augers, B, and the twist gimlet, C, do possess this feature in the tapered screw. But they have disadvantages in other respects, in consequence of which they are unsuitable for work demanding a high degree of accuracy The numerous centre bits possess the centring faculty in varying degrees, because the hole is started by the tit placed in the centre, before the cutting edges come into action. Around this principle designs are varied to obtain equally balanced cutting forces, to produce clean severance of grain with the least effort, and to facilitate the escape of chips with the minimum of friction. From these points of view the common centre bit [40], A, is the worst of its class, because its cutting action is unbalanced. It has one nicker, *a*, and one cutting lip, *b*, on opposite sides of the tit. Directly the cutter, *b*, begins its work, practically all the stress is thrown upon its side of the centre, with much torsional effort. Its cutting edge also is too wide for easy work, hence these bits tend to *run*, and they will not bore with fair truth except in plank way of the grain. Try them in end, or diagonal grain, and they are almost useless. Neither is the tit of triangular section a good form for centring, hence many recent bits have a screw instead, B, but the other objectionable features remain.

Balanced Bits. Contrast this with the later forms [41], the Gilpin, the Jennings, the Irwin, and others. These comprise a fine central screw for centring, two nickers, and two cutters on opposite sides. Or cutting is an operation done without separate nicking, and the lips are generally formed in some fashion or another to give a shearing or detailed cut, and so lessen the severity of the task. In 41, A is a Jennings bit with screw and nickers; B differs in having double nickers, or *spurs*, going down and up, the latter helping to get the chips out of the hole; in C the spurs stand upwards only In Gedge bits, D and E, the curved cutting edges cut very sweetly, on the same principle that a gouge severs more material with less effort than a chisel does, due to the shearing action. E is a solid-nose auger, the chips passing up through the holes in the nose. F is a screw auger with lips which neither stand up or down; G and H are Irwin bits, or augers in two forms out of several, the features common to all being the solid circular forged shank. In the examples A to F, provision for getting out the chips, absent in the centre bit [40], is secured by the spiral twist. In some also the turned up lips assist in lifting out cuttings from deep holes. The spiral in A to F is imparted by twisting a flat piece of steel into a helical form. In G, H, and others the shape is that of a small cylindrical stem with a deep helix around it, and it is claimed that there is less friction and more strength in this form than in the other Some of these, termed *auger bits* and augers, are made in the same designs, but of larger size. These tools are made for use by hand and by machine also.

All these are rigid tools, each capable of boring only one diameter. The principle of adjustability is embodied in the expansion centre bits and the hollow augers, the first for holes, the second for pins and dowels. In the first [42] the cutting lip is adjustable to a considerable range of radii, and is clamped by a screw. Graduations on the face enable the diameter to be read. These bits will bore the exact size specified; centre bits always bore larger than the normal diameter. The hollow auger [43] has two adjustable knives, *a*, pinched with set screws, to produce a moderate range of diameters.

Well-sinker's Tools. The boring tools are not exhausted by the metal and wood workers. The well-sinker uses them for boring hundreds of feet down into the earth's strata. These are formed on identical principles with the others, but they are attached to rods, added lengths of which are screwed on as the depth of the boring proceeds. Some types predominate—the flat chisel, the tee chisel, the clay auger, and the circular chisel. A few are

shown in 44. A is a tee chisel. It combines the form of the chisel with the function of the drill. The curved side piece ensures the cutting of a circular hole by the rotation of the chisel. Flat chisels are used without the side piece, but they have to be lifted at every few inches and rotated rapidly. B shows four chisels mounted on a boring head. C is a circular chisel armed with teeth. Diamonds are frequently set in a tool of this kind, having a plain crown instead of teeth. They are used for drilling the hardest rocks, and often cost hundreds of pounds each. Ordinary rocks are pierced by rock drills. Some have four edges in the form of a cross, usually of chisel shape, though varied in forms, D. These are used in percussion boring, being lifted, dropped, and rotated, so breaking up the rock and producing round holes. The chips are removed by other tools termed shells. Clayey soil is removed by clay augers.

Tools for Screw Production. Few except engineers are aware of the large numbers of diverse tools and machines which are used in the formation of screw threads. The dimensions of screws, the degree of accuracy demanded, and the quantities required are the principal causes which control methods. And within each governing condition there are many methods, and many designs by which similar results are attained. The subject of screws, and the tools and machinery for producing them do, in fact, give sole occupation to numerous firms.

Screwing tackle may be broadly divided into two groups, one being that in which the cutting tool or tools have one function only, that of producing the correct section of the screw thread, the pitch and diameter being controlled by extraneous devices. This is the method of the screw-cutting lathe, the chasing lathes, and the hand-operated comb, or chasing tools. The other group comprises tools which not only produce the sections of the threads, but also size and pitch correctly. These include the taps and dies, both hand and machine operated, which, once started, have the capacity of self-guidance by virtue of the lead of the threads, and the use of three or more cutters in the circle.

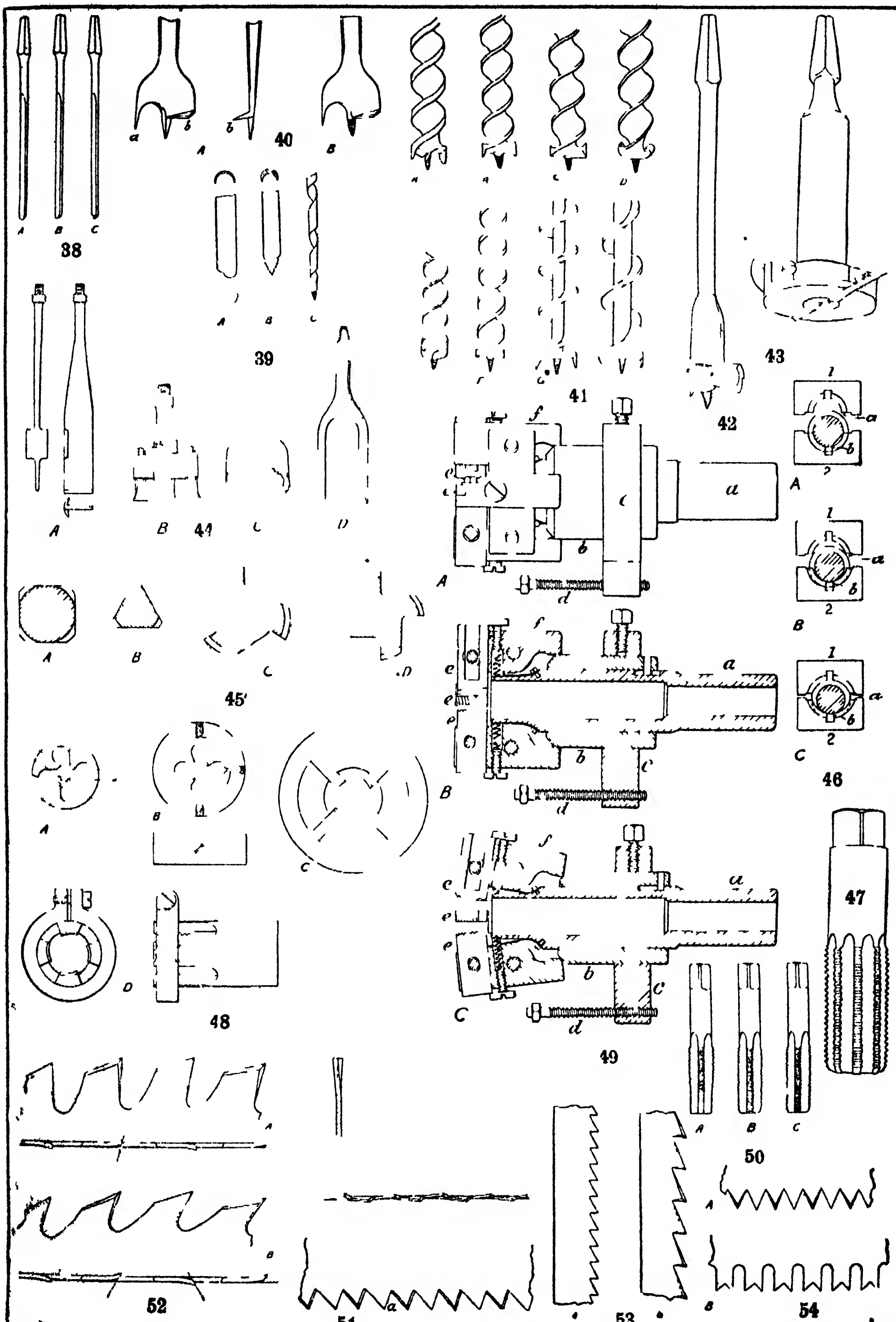
Of the first-named group little need be said. The methods of screw cutting in the lathe have been touched on in a previous article. With regard to the tools, they simply have the section of the thread, vee or square in plan, generally without top rake, acting, therefore, as scrapes. In square tools for square threaded screws, care has to be taken to give sufficient clearance at the leading edge, the amount of which depends on the slope or angle of the screw thread. The second group includes the common taps and dies, in which there are several important points to be noticed; and then the machine dies, which constitute a very large number, most of which are automatic in their action.

Taps and Dies. In their most elementary form these are simply screws adapted as cutting instruments. They have undergone a gradual process of evolution from forms in which friction and squeezing action were more in evidence as cutting, to present-day types, in which friction is of the slightest. In the old ones the screw threads occupied by far the largest portion of the circumference of the tap or die; in the modern types, the spaces predominate.

If we look at the tap and die in elementary forms, used still in small taps and screw plates, we see that a screw, external or internal, is made into a tool for reproducing other screws by cutting grooves down depthwise, the edges of which grooves act either by scraping, or by cutting.

Tap Sections. In the very smallest taps considerations of strength prevent them from being deeply fluted like those of larger size. Small taps—that is, those which are used with screw plates—are often of the sections in 45, A and B, in this respect resembling the flat-faced reamers, and coming, therefore, properly under the head of scraping tools. All taps were formerly of these sections. But taps of over about $\frac{3}{16}$ in., and even smaller in the best makes, are fluted, as at C or D, the front of the cutting edges pointing radially to the centre of the tap. Either three or four flutes are made, four being generally favoured, on account of the better guidance. A slight amount of clearance or relief is imparted to the back of the teeth by backing off the threads, C, D, in a similar manner to that described in connection with backed-off milling cutters. Formerly taps were relieved by tapering the entire thread down the length of the tap, but such is bad practice, and is never followed now, because the tap loses thereby its proper guidance. But backing-off can never be very pronounced because of the weakening effect of each on the cutting edges; hence the friction of tapping is severe. In the best taps there is seldom any front rake. But good results are secured by lessening the segments of the thread, either by increasing the number of grooves, or by giving them greater spacing, which applies to both taps and dies. Though the incisive action is not increased directly, it is indirectly, by lessening the amount of screw thread which is buried in the work, and thus lessening friction. Simple though these principles are, yet on the due balancing of the relations of these elements in die construction, and in a lesser degree in taps, depends a difference of perhaps 200 or 300 per cent. in rapidity of output.

Die Sections. In the dies the typical form is not so apparent. The cutting face is formed by grinding the leading edges, either parallel with the face of the die, or radial [46]. But it is obvious, on a moment's consideration, that the cutting action of either one of the edges or corners is of a variable character, because of the varying diameter of the thread which is being cut, and the unalterable size of the dies. Dies are cut over hobs [47], which are either one or two threads larger in diameter than the screws which they have to cut, and as the thread to be cut has two diameters, one at the bottom and the other at the top of the thread, true coincidence between thread and dies can take place only in one position.



TOOLS FOR BORING, SCREWING AND SAWING

38. Woodworkers' bits, of shell and allied types 39. Nose and gimlet types 40. Common centre bits 41. Balanced augers and auger bits 42. Expanding centre bit 43. Hollow auger 44. Well-sinkers' tools 45. Sections of taps 46. The action of screwing dies 47. Master tap 48. Spring dies and chasers 49 Opening die head 50 A set of taps 51. Handsaw teeth 52. Circular saw teeth 53. Band or frame saw teeth 54. Cross-cut saw teeth

The action of the dies is seen clearly in 46, where 1 shows the position of the die when commencing to cut the thread, and 2 its position when the thread is finished, so that the cut is commenced with the corners *a*. Then as the thread deepens they are thrown off, and a squeezing action occurs between *a* and *b*, and afterwards the corners *a* quite cease to cut, and all the work is therefore thrown upon the internal corners *b*. The only angle of clearance then is that slight amount which is present when the surface of the thread being cut is not in exact coincidence with the surface of the die—that is, at the periods when the corners *a* or *b* are actually cutting. Also, the slight alteration in the angle of the thread, which is continually taking place as the diameter of the screw is being reduced, throws extra work on the dies, causing excess of friction. It is thus apparent that dies are not good cutting tools. Chasers are superior as cutting tools, because they have the proper angles readily imparted to them.

Out of this action arises the question of the best curvature to impart to dies. As these are cut by a hob or master tap [47], their curvature is obviously that of the tap, and unalterable. In 46, A shows a practically impossible form in hand dies of the style shown, cut over a hob of the same diameter as the thread to be produced. Obviously, though these would cut at the start, 1, at the finish, 2, the cutting action would have ceased. But in those shown at B, made over a hob one thread deeper than the thread to be cut, they are still operative at 2 when the thread is down to size, for the edge *b* still has relief, due to the difference in curvature of the thread and the die. At C, dies cut over a hob two threads deeper than the screw to be cut do not cut well at first, but when the thread is finished they are fully operative.

Now, though these are, and have long been, the standard design used in England for hand dies, they are not the best possible. American dies have wider spaces, and smaller arcs in operation Fig. 48 illustrates a few.

American Dies. The feature in these is that they are solid, and do not therefore permit of being closed inwards at intervals as the thread is cut, like the dies just illustrated. One run over is sufficient to cut the screw, and there is far less of the squeezing action which causes the ordinary dies to work so hard. The appearance of a solid die in plan is shown in 47, A. The cutting faces have a slight amount of front rake, and the dotted lines indicate the relative angles of the faces behind the thread, which slope away in a direction that gives strength to the die. The threads are backed off to give clearance similarly to taps. Although these are solid dies, provision is introduced for varying the diameter of the screw cut, either to compensate for wear of the die, or to effect differences in the fit of screws in their holes, tight or easy, as desired. A common method is that at B, where the die is split at one side, and being placed within a ring or *collet*, is expanded by screwing in the pointed screw at the side, or contracted by the two screws at right angles; the elasticity of the die being sufficient to allow of a small amount of springing. There are many other devices for producing the same effect, being chiefly tapered or pointed screws. The outer collet is held in the die stock, or, in the case of lathes and screw machines, in a circular body.

In some dies, especially those of the larger sizes, steel is saved, and convenience of grinding secured by fastening flat pieces, or *chasers*, in a body, C, provision being made for easy removal, and for adjustments to and from the centre. Another class of die, D, used on some machines, has four or more cutting portions and is encircled by a clamp ring, so that the die may be closed in or allowed to expand in order to thread to very fine limits. Sharpening is easily done by means of a grinding wheel passing down the flat faces in the gaps.

Machine Dies. The dies for use in machines are much more elaborated than the taps. There are some dozens of different designs of these *die-heads*, as they are termed. But they nearly all have the property of adjustment, or *sizing*, to compensate for wear, and to work to minute limits of tolerance. Hence the mechanism in some is highly elaborated. In the simpler forms, used largely in screw machines and turret lathes, a spring action is embodied, the dies being split as in 48, and encircled by a ring or collar by which they can be closed to a minute amount from time to time. In others, the closing in or opening out is effected in a way which is regulated by graduations, so that the diameter of the thread can be read on the edge or face of the holder. In more advanced designs provision is made for the automatic opening of the dies when a thread has been cut, in order to avoid the reversal and running back of the die off the thread. These are *self opening dies* a numerous group. In all, the flat chasers are used, of the style C in 48. All these make an interesting and wide study in themselves.

Opening Die-heads. In the opening die-heads mechanism is included by which the chasers, usually four in number, may be suddenly drawn back from the thread, so that the head can be withdrawn by the turret in which it is held. This movement of the chasers is either a direct radial one, the chaser holders sliding in grooves, or a pivoting action is given, an example being shown here. A stop piece is provided, which is struck sometimes by the end of the work, sometimes by a part of the machine, to cause the chasers to fly open, under the pressure of a spring When another thread has to be cut they are closed in again by hand, or automatically, and the cycle is repeated. Previous to the introduction of these time-saving die-heads, the direction of rotation of work in the screw machines had to be reversed, so that the head ran itself off the thread.

The Tucker die, made by the Pratt & Whitney Company, may be taken as an instance of the pivoting type [49]. In the three views, A shows the outside elevation and B a section with the chasers closed in, while C indicates the appearance when opened off the thread; *a* is the shank, held in the turret hole, and carrying a sleeve, *b*, which has a limited amount of sliding motion.

A ring, *c*, is fixed in any position on *b* by a set screw, and a long screw, *d*, in *c* projects out more or less as required, so that it may be struck by a portion of the machine when the turret has travelled up to the required distance. The result of striking *d* is that *c* is slid back, carrying with it *b*, which causes the dies to open, in the following manner. The chasers, *e*, are clamped with square-headed set screws, and adjusted with slotted head screws endwise in holders, *f*; the latter are pivoted in a ring, and coiled springs are inserted in the holes below the slotted screws which adjust the chasers. The flat springs shown in black on the end of the body, *a*, serve to keep out dirt and cuttings. It will be seen that as long as the sleeve, *b*, remains in the position shown at A and B, the dies are closed, ready for work; but when the thread is finished, and the screw *d* struck, *b* is slid back and its bevelled end allows the ends of the chaser holders, *f*, to slip down, the coiled springs mentioned causing the tilting action, the result being that shown at C. Reclosing is effected by sliding the ring, *c*, and sleeve, *b*, back again to the position at A.

Kinds of Taps. Leaving the sectional forms of taps and dies, we note the longitudinal shapes of taps [**50**]. In taps operated by hand, two separate ones are required to cut a thread, and in some cases three. First, as the tap must enter a hole of the same diameter as the bottom of the thread, the lower portion of the tap is ground away to that diameter, thence tapering upwards until only about five complete threads are left at the top. This is the *entering* or *taper* tap [**50**], A. The next, or *middle tap*, B, has all its threads full, save four or five at the bottom, and this completes the thread, provided the hole is a *thoroughfare one*, so that the tap can run right through it by four or five threads. But if a hole terminates in a blank end the *bottoming* or *plug* tap has to finish. This has full threads to the end, C. The illustrations are those of American taps, in which the same proportions exist as in dies—namely, narrow cutting arcs and wide spaces. English made ones have about twice the width of threads. Machine taps are longer than hand taps, often very long, and they are gripped differently. When very exact dimensions are required, expanding taps are sometimes employed, in which the cutters are capable of radial adjustment, similarly to those of the reamers.

Saws. Saws include both scraping and cutting tools, whether we regard the action of individual teeth or their total action. It is seldom that the angle of front rake is less than 90 deg.—it is usually more, the teeth leaning back, in most saws, until we arrive at the equilateral triangular form of the cross-cut and hack, or metal-cutting saws. Hence the material is removed as dust, except in the case of very wet stuff, when it becomes somewhat stringy, but never approaches to the character of a shaving. Yet, viewed in one aspect, most saw teeth have a formation which causes their action to approximate to that of true cutting tools. All saws, except those used for metal, are sharpened at a bevel, by which friction is diminished, the saw cutting sweetly and attacking the material in an oblique line, with a resulting shearing operation. Thus, in **51** and **52** bevelled lines represent the direction in which the file is held when sharpening the tooth faces, so that the tooth face meets the material like the iron of a skew-mouthed rebate plane, or like a turning chisel. Though the tooth is so thin, this bevelling exercises a very marked influence on the sweetness of the action of the saw teeth.

Forms of Saw Teeth. There are various practical considerations which govern the sizes and forms of saw teeth. The main requisite to be fulfilled is that the teeth shall operate as freely as possible. As a general summary, we may say that the harder the material the greater the backward slope of the faces of the teeth; in technical language, the less *rake* present, and the finer the *pitch* or distance between teeth, relatively to the size of the saw, the less the *set*, or amount by which the teeth are bent to right and left of the plane of the blade.

Teeth, when cutting through wet wood, must have more set than those working in dry stuff, because the material removed is more apt to clog and hinder the saw's action, and they require larger pitch, which means more *spacing* in order to allow freedom for the dust to get away without choking.

The Set of Saws. In many saws, especially for metal, the set is imparted by a thinning back of the blade behind the teeth. Fig. **51** may be termed the hand saw type of tooth, varied in the slope of front and back rake, and in sizes of teeth. It will rip, or cross-cut hard or soft wood, but is more suitable for the first kind than the second. For soft wood only, the front, *a*, of the teeth, should be nearer the upright position, and the backs might have more slope. The set seen in the plan [**51**] is slightly exaggerated, being suitable only for use in cross-cutting soft woods. For ripping hard or soft woods its amount should be considerably less.

Fig. **52** illustrates the teeth of circular saws for hard and soft woods. The teeth of A have little rake, those of B have. A has less set than B, and its sharpening angle is less, as indicated by the dotted lines. Note the large size of the *gullets*, which are necessary to permit free escape of the sawdust. Rapidly running saws, like circulars, require more space than the hand, or pit saws, or even the frame saws.

Fig. **53** shows the blade saws, used as band saws and frame saws. A would be suitable for hard woods, B for soft. Fig. **54** illustrates two types of cross-cut, the triangular toothed A, and the M-toothed B, variations in which occur. They scrape only, and operate equally well in both directions.

Saws are either *rectilinear* or *continuous*. To the first class belong the hand, tenon, bow, fret, compass, cross-cut, and kindred kinds. To the latter the band, circular, and cylindrical forms, all of which are too familiar to call for any observations or illustrations.

Continued

Continued from page 4315

ACCORDION, FLAGEOLET, & CONCERTINA

Construction and Peculiarities of the Instruments. Attitude of Player. Fingerboard Scales. Positions. Exercises

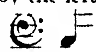
By ALGERNON ROSE

ACCORDION

The accordion or melodeon may be regarded as a large edition of the mouth organ, its sounds being obtained much in the same way. It consists of a pair of oblong shaped hand bellows with seven or more folds. To the right side of the instrument is affixed a number of levers arranged in rows. Sometimes these keys are like the stops of a concertina. According to the make of the instrument, so there are 8, 10, 12, or 21 keys. Besides these, there are three larger valves, known as the wind, accompaniment, and bass stops. In the largest variety there are 21 keys in two rows. The upper series gives an irregular scale of G major [Ex. 1].

An inverted V over a note implies that the bellows have to be drawn out. Notes without such a mark are obtained by pressing in the bellows. The lower series gives the scale of C major [Ex. 2].

Each key or lever sounds two notes. The first is produced when the bellows are pushed in and the second when they are pulled out. The reason for this is that as each key is pressed a valve inside the hand board is opened. Within the opening are two little tongues of metal, one bent forward and the other backward. According to the small or large size of the tongues so is the pitch of the sound produced high or low. When a valve is opened and the air is compressed it causes one of these tongues, or reeds, to vibrate quickly, and its motion magnified by a sound-board, causes the musical tone. Then, when the bellows are expanded, the other little tongue is made to vibrate by the opposite current of air. Thus the second sound is produced.

The best way of playing the accordion is to rest it upon the knee. By making a pivot of the knee a pushed bass note and a pulled melody note may be sounded at the same time. Pass the right thumb through the loop provided for it. This leaves the other right fingers free to press the keys. Put the left hand on the other side; its chief duty is to work the bellows. According to the force used in pressing or drawing out the latter, so is the intensity of the tone regulated. It requires considerable skill to make a good crescendo or diminuendo. An overblown accordion sounds at its worst, whereas when played with even softness it is often heard at its best. Place the second and third left fingers through the strap; the left thumb can then press the wind stop. The bass valve is worked by the left little finger. It gives two deep notes, C  when the bellows are pressed in, and G below the C  when they are drawn out. The first left finger is used for the accompaniment stop.

Ex. 1

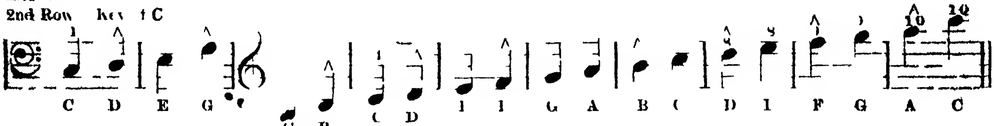
ACCORDION with 21 KEYS

1st Row. Key of G

Up to the sixth key the bellows have to be pressed in to get the first note, then for the notes which follow they have first to be drawn out.

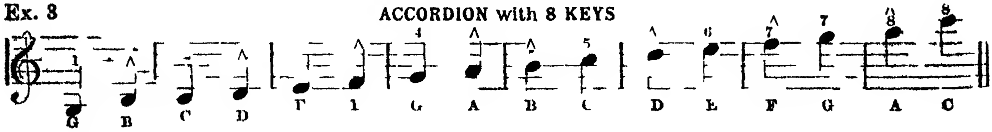
Ex. 2

2nd Row. Key of C



Ex. 3

ACCORDION with 8 KEYS

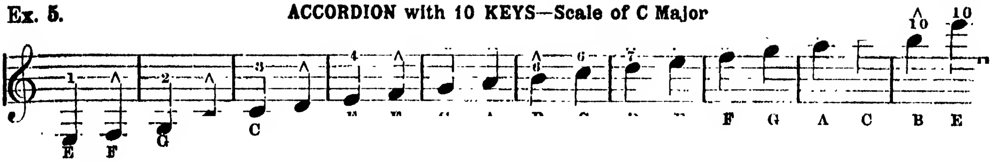


Ex. 4.

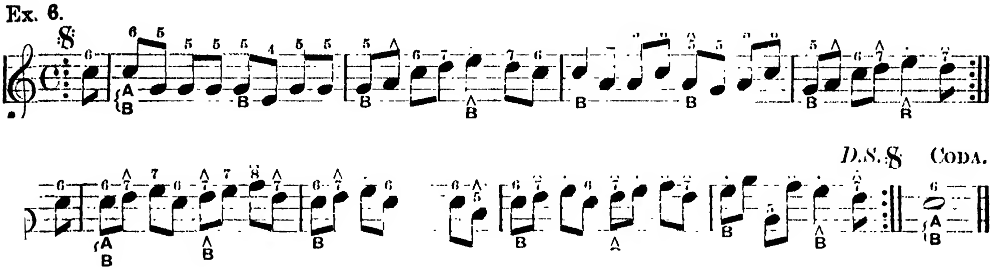
ACCORDION with 12 KEYS

8vo lower

Ex. 5. ACCORDION with 10 KEYS—Scale of C Major



Ex. 6.



This gives the chord of the sub-dominant of G when the bellows are pushed in  and the chord of the tonic of G when hey are pulled out , a couple of chords such as an organist in church usually employs for the "Amen."

The student who wishes to make the most of this instrument should peruse the course on Harmony [page 37], in order to avoid sounding the accompaniment and bass stops with wrong notes of the melody, as is done by unmusical street players. Nevertheless, the best of these instruments, when performed upon skilfully, are not without a certain artistic value. As an incentive for the non-musician to prepare himself to learn the English concertina, the accordion has been, and is, undoubtedly helpful.

Before beginning to play, press the wind stop. This inflates the bellows. If they are already full, and a "drawn-out" note has to be sounded, press the stop to let some of the air escape. The bellows can then be further drawn out and the necessary notes obtained.

Having given the notes for the accordion with 21 keys, for the sake of reference we tabulate the scale of the smallest variety, that with 8 keys [Ex. 3].

The scale of the accordion with 12 keys is given in Ex. 4.

But the most popular style of accordion at present sold is the instrument with 10 keys. We have therefore reserved the fingering of its compass [Ex. 5] to the last.

B means bass stop, A accompaniment stop; if both letters occur together, both stops must be used at the same time.

As an exercise, in conclusion, the student who has followed these instructions carefully may practise with profit the quaint old country melody which is given in Ex. 6. Strict attention must, however, be paid to time.

FLAGEOLET

The English instrument has six finger-holes. From these three octaves and a half, with all the intermediate semitones, can be produced, if the student only knows how.

The cheap flageolet can be bought in various sizes. They are all fingered alike, but the longer the tube the deeper the tone. Get the most usual size, marked "D." Its lowest note should be in tune with the D below treble staff.

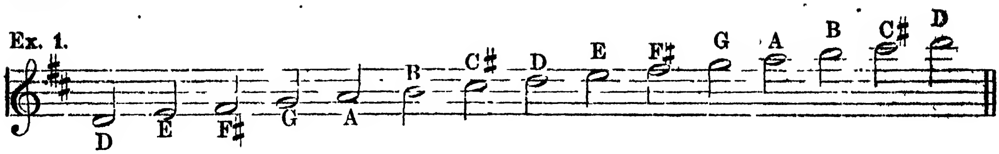
Cause of the Tone. Everybody is familiar with the tin whistle, but few understand that the whistle, in itself, has no sound. The plug of wood filling up most of the tube forming the mouthpiece serves to shape the breath into a thin flat sheet. This air strikes against the sharp lip, slightly bent in, of the aperture, the result being that the sudden contact brings about those pulsations or vibrations, which produce the musical tone. Do not play the top notes with the right hand. The left hand must finger those nearest the mouthpiece, and the right hand the three lower notes.

Place the left thumb behind the upper half of the tube and let the right thumb steady the lower half. Keeping the fingers off the holes, blow gently. This (in a "D" tube) sounds C♯, nearly an octave above the lowest D. Put down the first finger of the left hand. Blowing as before, the sound will be B, third line treble clef. Depress the second left finger to get A; the third left finger for G below; the first right finger for F♯ (in the key of D major); the second right finger for E; and the third right finger for D. All the holes are now covered.

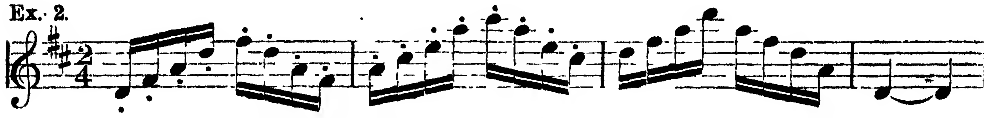
Natural Notes. Now tackle the scale of D major, uncovering the holes successively and sounding the notes softly as the scale is ascended. [Ex. 1.]

After reversing the order of the six notes first played, to get the octave D above the lowest note, put down all the fingers excepting the first of the left hand. Blowing with somewhat more force, take off the third right finger as the first left finger is put down, the octave above the previous E sounded will be heard. To get F♯, G, A, and B, uncover the notes exactly as before,

Ex. 1.



Ex. 2.



but increasing the pressure of the breath. The reason for this increased pressure is that the air-motion inside the tube needed for a note of high pitch must be quicker than that for one of low pitch. For the lowest note, the breath must cause, as in the case of a string, the whole tube to pulsate in one large segment [see VIOLIN, page 2511]. By increasing the rapidity of the air, this segment splits itself up into two, and the same effect is obtained from a tube as from sounding only half the length of a string. For the octave above the C♯ sounded when all the holes were free, put down the second and third left fingers and the first right finger.

To get the next note, D, two octaves above the lowest sound, lift the first right finger. For the E above, open the two centre holes, but put down

Ex. 3.

the first and second left, and second and third right fingers. To get the F♯, two octaves above the first F♯, put down the first and second left fingers and the first and second right fingers. For the G, two octaves above the first G; depress the first, second and third fingers and blow hard. Lastly, to obtain the highest note the instrument gives, cover the four centre holes, leaving top and bottom holes open. Thus, the ordinary flageolet easily sounds nineteen notes. The beginner whose ear is musical will soon learn them, especially if he gets the sound he wants well into his mind by referring to a piano or harmonium. These are called the natural notes of the instrument, and suffice for the playing of ordinary tunes. If in earnest, the student may learn much on the tin whistle, which will be helpful, should he desire, later on, to take up the fife or flute. After memorising the notes given, he will soon be able to play by ear "God Save the King," "Home Sweet Home," and other familiar melodies. Rather than wasting his leisure in such a way, we would point out the desirability of practising daily, in correct time, exercises which will familiarise him with the fingering of the instrument, because, without such training, he can never hope to excel. [Ex. 2.]

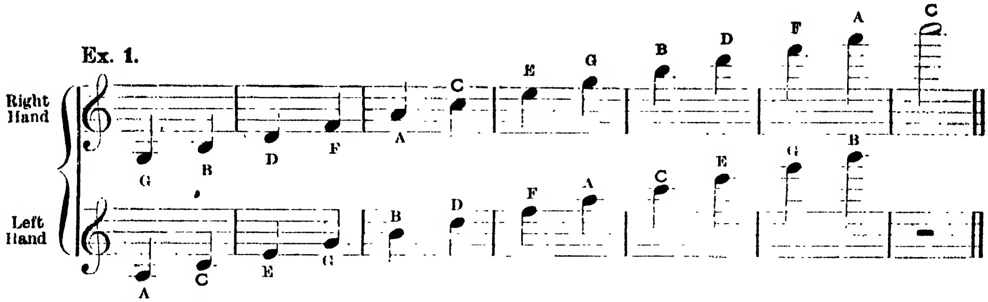
In this exercise each note must be played distinctly and with a separate breath. Do not hurry. The main point is to play slowly and steadily in correct time. Make each sound last during so many ticks of a clock. Increase the speed gradually by diminishing the number of ticks, but avoid playing three or four notes quickly, then pausing to find out the next, and then making another rush. Next try playing several notes with one breath, so that they appear to be linked together by a slur. [Ex. 3.]

Chromatic Scale. We now come to a greater difficulty, which ordinary players imagine is impossible of accomplishment on a flageolet without keys. It is to insert between the natural notes those sharps or flats necessary to enable the player to run up or down the scale by a series of semitones. This is done partly by difference in fingering and partly by the graduated force of the breath. If mastered, it enables the student to play in almost any key, and invests his instrument with musical attributes unknown to ordinary players. The student should, therefore, not rest content until he has made himself thoroughly familiar with this fresh complication. Sound the low D as before, with the six holes covered. To get D♯, blow a little more strongly. "Will" to get the half-tone above. The sound wanted will come. Take off the third finger for E. To get F♮, half a tone above, lift the second right finger, blowing softly. As the instrument is in D, and D major has two sharps, F and C, the next natural note will be F♯. Play that as before, by taking off the second and third right fingers. Sound the G as before by taking off the first right finger. For G♯, take off the third left finger, as for A, but put down the first, second, and third right fingers, blowing softly. Sound the A by removing the three right fingers.

To get A♯, take off the second left finger as for B, covering all the other holes. Sound B. To obtain C♮, take off the first left finger as for C♯, but put down the second left and the first and second right fingers. Play C♯ as before, with all the holes open, and D, an octave above the lowest sound, by closing all the vents, excepting the top one. To get D♯, do precisely as for the previous D♯. Make E, F, F♯ and G as before, altering the pitch by increased pressure of the breath. To get the G♯ an octave above that first sounded, finger as for A, with the first and second right digits down; close the fourth hole with the first right finger. Sound the A as before.

For the A♯, an octave above the first A♯, finger as for B, with the first right finger down; but put down also the third right finger. To get C♮, an octave above the first C♮, finger as for C♯, with the second and third left fingers and first right finger down, but depress also the second right finger. Then take off the

Ex. 1.



latter for the C♯. Take off the first right finger for the D. To get D♯, put down the second and third right fingers, as for E, also the second and third left fingers. Then lower the first and second left fingers as before for the E. To obtain the F♯ two octaves above the first F♯, put down the first and second left and first and second right fingers, and blow hard. Sound top G as before, with the first, second, and third left fingers.

For G♯, two octaves higher than the first G♯, when all the notes were closed except the third, reverse the process by leaving all open except that hole. Lastly, sound top A as before.

Exercises. Facility in playing chromatically cannot be gained all at once. But as the rules controlling the production from a simple pipe of the different sounds enumerated are governed by acoustical laws, they apply not alone to the flageolet, but to other tubular instruments proportioned in the same way. The sooner, therefore, the student familiarises himself with them the better, although later, the necessary sharps or flats may be obtained more conveniently by keys.

CONCERTINA

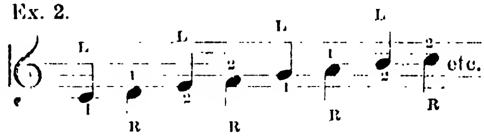
The musical student who has an opportunity of becoming the possessor of an English concertina may rest assured that it is well worthy of serious attention. It is no mere toy, as is too often supposed. Not only has the concertina great purity of tone, but it is capable of remarkable rapidity of execution, whether in single or double notes. Moreover, the simplicity of its fingering and power of crescendo and diminuendo are most effective. The English concertina, being furnished with a double action, produces the same note both on drawing out and pressing in the bellows.

Not only is it capable of being played in any key, but in some ways it is superior to the pianoforte, owing to its power of sustaining and modulating the tone, its portability making it possible to be carried from place to place, and its smaller cost which places it within the reach of more pockets. Without difficulty the executant can negotiate intervals of thirds, sixths, octaves, tenths, and extended harmonies. At the same time it is capable of performing music written for the flute, hautboy, etc.

A Minor Derangement. The only trouble this instrument is likely to give a player is when a note sometimes goes dumb. This is usually caused by a particle of dust getting between the frame and the vibrator. Loosen the six screws in the plate of the side which needs attention sufficiently to allow the action to be removed. Take out the action. The note will be easily discovered, as its name is stamped on the top of the frame. Displace the reed by drawing it from the groove. Hold it up to the light. The dust which interferes with the sound will be visible. Remove this with a penknife. In replacing the parts, note that R and L stand respectively for the right and left hand. These letters must correspond with the R and L and number on the top of the pan to ensure correct adjustment. Observe the same figures in replacing the action.

The complete concertina family consists of four instruments. First, we have the soprano, used

Ex. 2.



for solo work, with a compass of three and a half octaves from fiddle G, two ledger lines below treble staff. The tenor, bass and double-bass concertinas extend the compass downwards, so as to make altogether six and a half octaves.

Attitude. The concertina may be played either sitting or standing. To diminish the weight on the thumbs, especially with the larger patterns, a ribbon is secured to the middle buttons and carried round the neck. Be careful, when the instrument is played sitting, that the folds of the bellows do not rub against the clothes or dress. Place the left-hand side of the instrument on the left knee. Each thumb must be passed as far as the first joint into the loop provided for it. If this is too tight, or too slack, regulate it by screwing or unscrewing the metal button. Place the fourth finger lightly in the finger rest. It should stop there except when, by moving it, the hand can assume an easier position while playing. Do not draw out or press in the bellows unless a key is touched. The pressing in and drawing out is done with the right hand. Force of sound depends on the degree of pressure or pulling applied.

The beginner should practise his exercises at first with the least degree of force. It saves the wear of the instrument, and makes it almost inaudible in another room. To facilitate the pressing in or drawing out, rest the fleshy part

of the hand against the instrument. The attitude of the player should be natural. Keep the position of the arms easy. Never overforce the bellows. This produces a discordant sound, and is sometimes injurious to the instrument. Draw out and press in steadily, in a straight line. Do not turn or twist the instrument. Cultivate a habit of pulling out to the full extent, and then pressing in without break in the sound. Do not change the direction of blowing in the middle of a phrase. Exactly as the lungs act when singing, so let the instrument take a fresh breath before and after a passage. Utilise any rest which occurs for such inflation. Remember that lower notes require more reserve force than upper ones.

Fingerboard. The system of fingering and position of the notes on the English concertina make it distinct from any other musical instrument, and give certain peculiarly artistic attributes. On either face there are four parallel rows of stops. The two centre rows are akin to the white keys, or naturals, on a piano, the outer, or first and fourth black rows, furnishing the sharps or flats. The C's, to distinguish them from the other notes, are coloured red, an idea probably borrowed from the harp. The treble concertina usually has 48 keys, comprising 25 naturals and 23 accidentals. Now, when the thumbs are in the loops, the first finger negotiates the whole of the second column of keys, that digit being moved to the first row when required. The second finger negotiates the third row, and the third finger the fourth row. The place of the little finger is, as has been mentioned, on its rest, except when it is used to simplify execution. When sounding passages of sixths, octaves, and tenths in sharp or flat keys, it is of particular service. Finger pressure must be elastic and delicate, but firm. Do not thump the studs. Let the finger tips glide from one note to another.

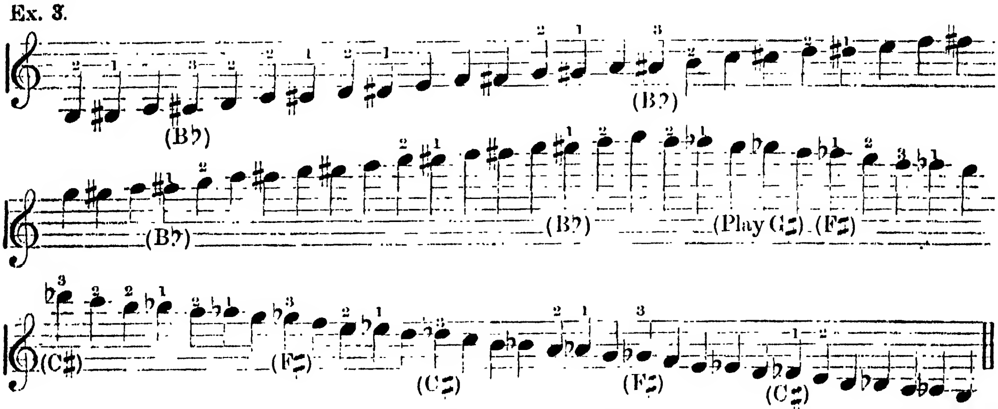
For staccato playing, however, raise the finger slightly above the note, so that it may be struck sharply, and immediately released. In passages which are slurred, each note must be held down until the next finger is ready, that there may be no break between one sound and another.

Scales. Take Ex. 1. Here we give two staves. The top staff shows only notes which are on the spaces, whilst the bottom staff only those notes which are on the lines.

Thus G is the lowest of the second column on the right hand, and A the lowest note negotiated by the second finger of the left hand. B is the lowest played by the second right finger; C, the lowest played by the first left finger; and so on, zigzagging from key to key. To run up a scale, therefore, the hands are used alternately, whereas, on a harmonium, one hand has to do the work alone. The difference in fingering thus between the two instruments is capable of producing quite different effects. Play the natural key of C [Ex. 2].

Chromatic Scale. The chromatic scale is important and needs daily repetition. Be careful to press each note equally, so as to obtain evenness of tone. Practise slowly. The student should observe that the concertina, unlike the piano, has separate notes for G♯ and A♭, and for D♯ and E♭. These are not tuned in unequal temperament, but are added in order to simplify the fingering. Therefore, when D♯ or G♯ is required, play the note next to D♮ or G♮. When A♭ or E♭ is needed, press that next to A♮ or E♮. [Ex. 3.]

Ex. 3.



Although, as a general rule, each column of keys is manipulated by the same finger, certain effects are facilitated by repeating the same notes with different fingers. In such a case, keep the two fingers used for the change close together to avoid unnecessary movements.

If artistically produced, the *tremolo* effect closely resembles the human voice. It should be done by making the finger quiver over the note itself, and not by shaking the bellows.

If the student forgets the place of any note, looking at the instrument itself is a bad habit. When the thumb is placed in a loop and the little finger in its rest, the second finger of the right hand should drop upon the red note, C. and the second finger of the left hand upon B. Those two notes are useful guides to the beginner in finding the others, but the best way of impressing their position on the memory is for the student to make a diagram of the four columns of keys for each hand, adding to them the names of the notes. If he has this diagram before him, he will see at once the position of any key.

Accordion, Flageolet, and Concertina concluded

PRINCIPLES OF CHEESEMAKING

Necessity for Rich Milk and Pure Water. British and Foreign Cheeses. Processes Used in Making Cheese. Rennet. The Uses of Bacteria

DAIRY FARMING
continued from page 4281

By Professor JAMES LONG

ALTHOUGH our forefathers are often credited with great skill in the production of fine cheese, we may take it for granted that, except perhaps in occasional instances, nothing was produced in the past which can compare in quality with the finest cheese that is made to-day. This fact is owing to the formulation and comprehension of principles. The reasons for the various operations are now known, and the maker is therefore placed in a position of control which enables him to conduct his work with much greater success and certainty. The object of the cheesemaker is to obtain a maximum quantity of cheese of high quality from a given quantity of milk; but he cannot accomplish this, however extensive his practice, without recognising the principles involved. The production of good cheese depends upon the soil upon which the cattle feed, upon the quality of the milk, and the skill of the maker, especially in his control of temperature and acidity. Cows fed on soil rich in lime usually produce milk which contains a larger percentage of lime than is common in milk produced on other soils, for which reason the acidity of the milk is slightly delayed, while a variation in the temperature, of the quantity of rennet employed, and the work of manipulation are often necessary. Difficulties which arise owing to the richness or poorness of milk in mineral matter and fat are easily removed by those who have mastered the principles involved, but they present striking obstacles to those who have not.

The Value of Rich Milk. To obtain fine cheese it is essential that the milk should be rich, a fact which has long been disputed, while quality also increases the yield. In the first place, then, rich milk produces a mellower cheese, for the reason that it contains more fat; while next it adds considerably to the weight produced per gallon, for not only does an increased quantity of fat tell, but with that increase, as we shall see later, there is also an increased appropriation of the casein and of the water employed. It has been estimated on the basis of exhaustive experiments that for each pound of fat present in milk the yield of cheese is increased to the extent of 2·7 lb. At the great American trials at Chicago, which were attended by the writer, the Jersey herd produced in one month cheese which was worth £11 more than that produced by a similar number of Shorthorns, although the latter breed is in England regarded as the best type of cow for cheese production.

Pure Water. It is important that in the cheese dairy the water employed should be of the purest, and that the food supplied to the cattle, whether on the pasture or in the stall, should be absolutely free from anything likely to convey an undesirable flavour or odour to the milk. The cheese plant or equipment should be of the best modern construction, intended to facilitate the work and to prevent as little trouble and difficulty in cleaning as possible. On these points the intending cheesemaker may obtain many hints by paying a visit to the British Dairy Institute at Reading, the Midland Institute near Derby, or the Scottish Institute at Kilmarnock.

Varieties. The principal varieties of cheese are set out in the table on the following page. Among minor varieties not referred to in the table are the Cotherstone (blue veined), the Slipcote (soft curd), the York (soft curd), the Caerphilly, the Dunlop cheese of Scotland, the Yorkshire cheese known as Liberton, the Wilts loaf cheese of Cheddar type, the blue skimmed milk cheese of Dorset, and a variety of local curd cheeses which include the New Forest and the Colwick. In France there are many varieties, apart from those mentioned, including the Coulommiers, which resembles the Camembert, the Mont d'Or, the Geromé, all of which are soft varieties; and the Livarot, a strong-smelling soft cheese made from skimmed milk. Germany, Denmark, Sweden, and other European countries, like America, have no special varieties of either pressed, blue, or soft cheese which are recognised upon the great markets of the world.

The Action of Rennet. In beginning the process of cheese manufacture, it is essential first to coagulate the milk. In some cases the evening's milk is kept until the morning, when the morning's milk is added under conditions which will be subsequently referred to. The milk having been brought to the required temperature—usually in a jacketed vat—and its volume ascertained, the requisite quantity of rennet is measured, mixed with four times its volume of water, and stirred in the milk. Where the evening's milk is kept until the morning, a slight amount of acidity will have developed, unless the temperature be low. As acid possesses a power of coagulation, it assists the rennet, and allowance must therefore be made on this score. The action of the rennet largely depends upon heat, for the quantity of rennet required is in an inverse ratio to the temperature of the milk, while within undefined limits the time of coagulation is in an inverse ratio to the quantity of rennet used. Thus, theoretically speaking, if one part of rennet converts 10,000 parts of milk at 95° F. into curd in forty minutes, it would coagulate one-tenth the quantity of milk in one tenth of the time, the same temperature being

THE PRINCIPAL VARIETIES OF CHEESE

ENGLAND

Cheese.	Temperature at which rennet is added.	Time occupied in coagulation	Composition: Water	Composition: Casein, etc.	Composition: Fat
	Degrees F		Per cent	Per cent	Per cent
Cheddar	84	40-50 min.	34	30	31
Cheshire	84	60 "	37	24	29
Leicester	78-84	90 "	33	29	29
Stilton (blue veined) .	80-90	50 "	30	29	35
Wensleydale (blue veined)	84-88	40 "		..	
Gloucester (double).. ..	..		36	21	27
Derby		.	31	21	35
Cream cheese . ..			30	5	63

THE CONTINENT

Cheese	Temperature	Coagulation	Composition: Water	Composition: Casein, etc.	Composition: Fat
	Degrees F		Per cent	Per cent	Per cent
Gruyère (France and Switzerland) . .	25	30 min	35	31	31
Cantal (France) .. .	90	60 "	44	25	21
Roquefort (France) (blue veined)..	..		31	27	33
Port du Salut (France) (soft, slightly pressed)	85	30 "			
Brie (France) (soft)	82-86	2-4 hr	59	17	25
Camembert (France) (soft)	80	2 "	40	29	30
Neufchatel (France) (blue)	90	2-4 "	44	15	34
Pont d'Eveque (France) (soft)	88	15 min		.	.
Gervais (France) (soft, part cream).. . ..	65	8-12 hr	53	12	30
Edam (round Dutch) .	84	15 min	36	24	30
Gouda (flat Dutch)	93	25 "	22	17	25
Parmesan (Italy)	77	20-30 "	31	42	19
Gorgonzola (Italy) (blue veined). ..	77-90	15 "	44	28	30

observed. But we have to deal with probabilities. Thus, the larger volume of milk would retain its heat more perfectly than the smaller volume, hence practice does not exactly correspond with theory.

Coagulation. Milk is set at various temperatures, in accordance with the variety of cheese to be made, a from 65° F. in small varieties made from a mixture of milk and cream, to 95° F., which is adopted in the manufacture of some of the pressed varieties. Rennet however, possesses very little activity below 65° F. The time occupied in the coagulation of milk, then, depends upon the temperature of the milk and the quantity of rennet employed. Thus, a small quantity of rennet prolongs the period, while a large quantity hastens it. These periods are further expanded in accordance with the temperature of the milk. In making firm or pressed cheese, forty minutes to two hours are usually occupied; but in making soft cheese, from two to fifty hours may be occupied. The higher the temperature, too, and the smaller the curd is cut, the more rapidly does it part with its whey; while the lower the temperature, and the larger the curd is cut, the more slowly it drains. Although drainage is promoted by cutting the curd fine in the hard cheeses, such as Cheddar, Cheshire, Dutch, and Gruyère, all are subsequently pressed for the removal of the surplus whey or serum. Blue-veined cheeses, like Stilton and Gorgonzola, however, are not pressed, while the delicate varieties of soft cheese, like Caerphilly and Port du Salut, are pressed but slightly.

Cutting the Curd. The true soft cheeses, whether ripened or fresh, as Brie, Camembert, or York, part with their surplus whey, by gravitation and evaporation; and here heat plays an important part, for unless the dairy employed be sufficiently warm the serum is held by the curd and the cheese spoiled; while if too warm the whey drains too freely, and the cheese becomes dry and inferior. The finer the curd is cut the larger the area of drainage. In the best varieties the curd is cut into cubes by the aid of two many-bladed knives, one horizontal, the other vertical. The whey is therefore induced to exude from each face of each cube, thus forming as it were by contraction a toughened coat, which largely prevents the remainder of the whey leaving the curd. When heated, however, as it usually is within the large volume of whey which has already collected, this whey is in large part removed, for heat assists the process of drainage. In making soft cheese, the tender curd is handled as little as possible; such cheese contains more moisture than pressed cheese, and care is thus taken to prevent its loss. The presence of more moisture in soft cheese means also the presence of more sugar, which is the chief cause of its more rapid fermentation. Where the temperature is too low, an excess of whey is retained in the curd, carbonic acid gas is formed, and the cheese swells and spoils. This especially applies to Stilton and other unpressed varieties.

The small cheesemaker often fails to produce high quality on account of the small volume of milk with which he has to deal. He is unable, unless very highly skilled, to maintain the heat necessary to perfect coagulation; nor is he often assisted by a perfect dairy apartment, the temperature of which he is able to control. In making cheese on a large scale, it should be possible to maintain a temperature of 65° F., while in a small dairy the average temperature should scarcely be less than 70° F.

Quantity of Rennet Required. Rich milk requires less rennet than poor milk, hence the importance of knowing the fat percentage. The quantity of rennet required and the time of coagulation vary with the temperature of the dairy, and therefore with the season and climate, which so largely control it. This, too, is the reason why more rennet is required in spring than in summer and autumn. It is essential that rennet should be carefully kept, that its strength may be maintained, and that the same variety should always be employed—a standard rennet being that in which one part coagulates 1,000 parts of milk in a given time at a given temperature. It should be

remembered, however, that as cows which have calved in spring fall off in their yield, their milk increases in quality, so that an alteration in the quantity of rennet employed may be necessary. Again, as lactic acid, which possesses the power of coagulation, forms more quickly in warm weather, there is a further influence which bears upon the quantity of rennet employed.

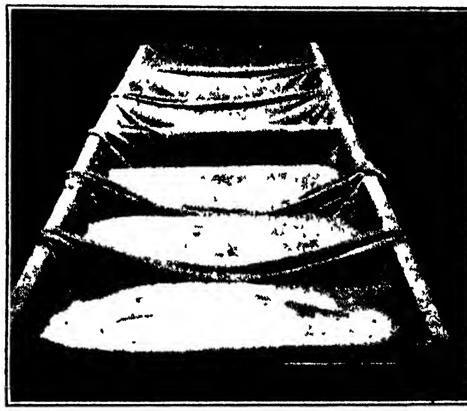
How and When to Remove Curd. In cutting or removing curd from the cheese-vat or tub, great care must be taken. It must not be cut too soon or too late, or roughly handled. If the tube of a glass thermometer be dipped in the curd, small particles will adhere if it is unfit; but if ready to cut and remove the tube will come out clean. If the curd has passed the proper period for cutting it will fracture, and whey will collect. As curd for pressed cheese is cut fine, as already remarked, that intended for unpressed and soft cheese, on the contrary, is removed in large layers or slices by the aid of hollow, plate-like metal skimmers. Dry curd, not the production of fine cutting, may be obtained, as in the manufacture of Stilton, by slightly longer coagulation and by the removal of large slices of curd at the right moment into cloths laid in suitable draining vessels [32], the cloths being subsequently tied from corner to corner, and tightened gently from time to time [33]. The temperature of the curd should exceed 70° F. If large pieces of curd are left after fine cutting, the presence of the whey within them will cause local fermentation, swelling, and damage.

Avoidance of Skimmed Milk. The employment of skimmed milk is fatal to both quality and quantity of cheese. In the manufacture of Cheddar, 1.13 lb. of fat should be present per lb. of casein; the proportion of fat, indeed, should never be below the proportion

33. METHOD OF TIGHTENING STRAINING-CLOTH
(From the Journal of the Royal Agricultural Society)

of casein. There is, too, a greater loss of fat in the making where skimmed milk is used at all. If cream be added to new milk, the loss of fat is diminished, while the weight of the cheese is increased by more than the weight of the increased solids added.

Source of Rennet. The rennet employed in cheese manufacture is an extract from the mucous membrane of the fourth stomach or "vell" of the milk-fed calf. No other material known to man can be employed for the same purpose in cheese production. Rennet is always reliable in action if pure and its strength main-



32. STRAINING-CLOTHS CONTAINING CURD
(From the Journal of the Royal Agricultural Society)

tained; it not only coagulates milk, but it helps to ripen the cheese, and unless it be imperfectly made, as we have seen it in Italy, where macerated pieces of the actual stomach of the calf are sometimes employed, it is never hurtful to cheese. Although occasionally made on the farm, rennet is now a standard product of commercial manufacture. It is sold in liquid, tablet, and powdered forms, the first named being the most simple and reliable; but its strength or quality varies in accordance with the make. The cheesemaker having selected a variety, should adhere to it, or he may spoil a batch of cheese. The coagulating power of rennet is affected by soda and other alkalis. Below 50° F. rennet produces no normal coagulation; between 100° F. and 108° F. its action is quickest, while from 108° F. to 122° F. the period of coagulation increases, partially losing its influence at the latter temperature. If we use too much rennet for a given quantity of milk, or adopt too high a temperature, the resulting cheese is tough; if we use too little, or adopt too low a temperature, the curd becomes too tender, the fat is lost, and the quality of the cheese diminished. The loss of fat is denoted by the whitish character of the whey, which should be clear and of a greenish tint.

Proportions of Rennet to be Used. It is important that rennet should be accurately measured, and either the ounce or the cubic centimetre (c.c.) may be employed. The latter is almost imperative in making soft cheese, but it is, under all circumstances, superior to the former. A measuring glass divided into hundredths should be used. There are 1,000 c.c. to a litre (10 litres = 2·2 gallons). If we take 1 c.c. of a standard rennet, therefore, and add it to a litre of milk at a temperature of 95° F., it will

coagulate in four minutes—assuming that the temperature is maintained constant; similarly, 10,000 c.c. (2·2 gallons) will coagulate in forty minutes. The principle involved in these figures should be especially recognised, but in all tests accuracy is impossible unless the temperature of the milk be controlled. If the time occupied in such a test be five minutes, instead of four minutes, it is proof that the rennet is not of a standard quality, but that 1 c.c. is capable of coagulating only 800 c.c. of milk; so that in practice if we employ it in our work we should require not 1 c.c. per thousand, but 1¼ c.c.

Value of Acidity. Acidity is imperative in cheesemaking, for upon it depends not only flavour, but mellow or salvy consistence. Acidity develops more freely in curd than in whey, but in practice it is whey that is tested. The proportion of acidity in the whey is now ascertained, and in the West of England experiments of Mr. Lloyd the best results were obtained when they contained ·22 per cent. of acid, as indicated by the particular method of testing which he employed. Excess of acid is fatal to quality in most varieties of cheese, but it is largely owing to deficiency that causes cheese made in spring to be inferior to that made later, for acidity is developed by heat.

In the manufacture of pressed cheese, like Cheddar or Cheshire, acid is developed by heating or "scalding" the curd and whey in the vat to a higher temperature. Where the curd is slowly formed, the acid present is larger in quantity; hence the excess of acid in tender curd which holds the whey longer than curd which is drier. In the manufacture of such a refined soft cheese as Camembert acidity is especially needed, as the moulds or fungi which are essential in the ripening process grow more freely upon the crust. As the moisture of this cheese evaporates during maturation, the *mycelium*—a network which is comparable to the tiny rootlets of a green or chlorophyll-containing plant—penetrates the curd and neutralises the acidity, with the result that the bacteria present are able to begin their work of decomposition, and the practical conversion of an insoluble to a soluble material. In curd which is drier than is necessary, there is less acidity because the sugar, the great medium through which it is produced, has largely escaped in the whey.

Scalding. The Cheddar manufacturer promotes the development of acidity by the addition of sour whey to the milk; but this plan is not essential during normal cheesemaking weather, or where the temperature of the dairy is under control. Acidity may be developed in the evening's milk, and this development may be assisted if necessary by scalding the mass in the process of manufacture. In spring, or on any occasion when the temperature is abnormally low, sour whey may be necessary, even though scalding be resorted to; but in all cases an allowance must be made for the increasing richness of the milk as the season advances.

The success of cheese manufacture largely depends upon cleanliness and the consequent prevention of the introduction into the milk of foreign or destructive bacteria, which are not only the cause of ill flavour and bad texture, but of abnormal decomposition and decay. This is particularly noticeable in the production of Stilton. In the manufacture of Camembert cheese, for example, it is practically proved that three varieties of bacteria are essential to success, while their activity and perfection of the cheese depend upon the presence of sufficient acidity.

Blue Mould. Again, there are many varieties of cheese, chiefly those which are pressed but slightly or not pressed at all, upon or within which the successful growth of fungi is necessary, and we may especially refer to Camembert, Brie, Coulommiers, and Neufchatel among soft cheeses, and to Stilton, Wensleydale, Gorgonzola, and Roquefort among blue-veined cheeses, in which the blue mould, *Penicillium glaucum*, plays a most important part. The spores or seeds of these parasitic plants are apparently present in the atmosphere of every milk-room, whether perfectly clean or the reverse. They find the curd of milk a suitable soil; but their successful culture depends upon moisture, air, and sufficiency of heat. They are practically excluded from growth in pressed cheese by the pressure which is exerted, while in cheese like Stilton, which is composed of pieces of unpressed curd, between which there is no real union, interstices are formed which leave room for the development of the spores. Varieties of soft cheese, such as those already mentioned, first develop a white, velvet-like fungus, which is followed by the blue, and in the Brie in particular by patches of a vermilion mould, believed to add to the piquancy of the flavour.

How Fat Affects the Weight. With reference to the influence of the solids of milk on cheese production, it should be pointed out that, as the result of experimental work of a most extensive character conducted at the stations in the States of New York and Wisconsin, it was found that with every increase of one pound of fat there was an increase of ·60 of casein and albumen and of one pound of water. When rich milk was employed, the percentage of solids extracted from the milk in the process of cheesemaking was larger than when it was poor in quality. The fat lost when the richest milk was used was ·17 per cent., while it reached ·49 per cent. when cheese was made from poor milk, the average being ·29 per cent., or 6¾ per cent. of the total fat. The quantity of casein and albumen lost under similar conditions was equal, on the average, to 23·3 per cent. of the total. On the basis of the work of one year, too, it was found that the green or unripe cheese produced per 100 lb. of milk was equivalent to the weight of the fat present in that milk multiplied by 2·75. Thus, if the milk contained 4 per cent. of fat, 100 lb., or 10 gallons of milk, produced eleven pounds of cheese, while where the milk contained 3½ per cent. of fat, which we may take as a fair average of the cows of our country, the cheese produced would reach 9·6lb.

Continued

EARTH AS THE HOME OF MAN

Distribution of Land and Water and its Effect. Climate and Temperature. Winds. Mountains and Rivers. Plains and Soils. Coasts and Tides

Following on POLITICAL GEOGRAPHY page 4290

By Dr. A. J. HERBERTSON, M.A., and F. D. HERBERTSON, B.A.

OUR survey of the world has brought out its great diversity. Few regions, if any, yield abundantly all that is required for the development of the highest civilisation. Commercial geography deals with the struggle of man to win subsistence in such a world. This he does partly by adapting himself to his environment, whether harsh or genial, and partly by attempting to modify that environment to suit his needs. One of his efforts in the latter direction is commerce, which seeks to equalise the distribution of useful commodities.

Two factors must be considered, the geographical and the human. The first deals with permanent geographical conditions, the distribution of sea and land, of heat, cold and moisture, which man can do little to modify. The second is concerned with man's increasing power of availing himself of the possibilities they offer.

The Land of the World. Only two-sevenths of the Earth's surface consists of land. Only two-sevenths, therefore, is fitted for the permanent home of man. The remaining five-sevenths consists of seas and oceans, at first a barrier, but often later a pathway to better conditions of existence.

The known lands of the world are about 52,000,000 sq. miles in area. Of this about twelve-thirteenths is grouped into two immense islands—the Old and New World. Australia accounts for nearly three-quarters of the remainder. By far the greater proportion of the land lies in the Northern Hemisphere. This results in a considerable extension from north to south, giving a complete series of climatic zones and consequently of economic products. It also brings the land portions of the world into closer proximity by contracting the breadth of the oceans between them.

The bulk of the land lies in temperate latitudes. With the exception of Greenland and a possible Antarctic continent, little land lies within the Polar circles. No part of the mainland of Europe reaches the tropics, and no part of the mainland of Asia reaches the equator, which crosses only two continents—Africa and South America. The dissection of tropical Asia into tapering peninsulas separated by wide seas, and the hollowing out of tropical America by the American Mediterranean, considerably reduces the area of the tropical lands.

The Influence of Climate. Of the factors affecting the distribution and development of the human race, climate is the most important. This is not because man is hypersensitive to extremes of heat and cold. On the contrary, he has a wider climatic range than any other living creature. The check operates indirectly through the great climatic sensitiveness of plants, on which both man and animals depend for subsistence.

Plants, which are fixed to the soil, have less power of adaptation than animals, which can move from place to place, and which, along with this mobility, and perhaps as a consequence of it, have developed great variability. Each family of plants is exacting in its demands. Tropical fruits, some of which for example, the banana —form the mainstay of large societies, require a high temperature to ripen them. Some, such as the coco-nut palm, prefer in addition proximity to the sea. The olive, a characteristic Mediterranean fruit, not only requires a rather hot summer, but cannot bear winter frosts. Hence it cannot be grown in Lombardy, where the summer temperature would suit it admirably. Maize needs a hotter summer than wheat, which in turn is less hardy than rye or barley. Not even the latter will ripen below a certain summer temperature, and within the Arctic circle the vegetable kingdom is represented chiefly by mosses and lichens. Still nearer the Pole even these disappear. Other plants require special conditions of moisture. Cereals are more sensitive to excess or defect of moisture than grasses, which thrive in regions too wet and too dry for the former. Rice, which needs swampy or flooded soil, suits hot damp climates, but cannot be grown in the hot dry climate which brings the date to perfection. Each group of economic plants therefore has a definite geographical range, a circumstance which influences not only the distribution of man, but even the type of civilisation within a given area.

Temperature: The Hot and Cold Lands. Temperature, one of the chief elements in climate, varies with distance from the equator and with distance from the sea-level —that is, with latitude and elevation.

The relation between latitude and climate has already been considered. [See page 293.] Here it is sufficient to recapitulate the main climatic divisions as determined by latitude.

1. Intertropical lands, hot all the year round.
2. Warm temperate lands, with hot summers and mild winters.
3. Cool temperate lands, with warm summers and cool or cold winters.
4. Polar lands, with long cold winters, and short cold summers.

The intense heat and moisture of tropical lands favour the growth of dense forests, but are not well suited to agriculture. Owing to the density of vegetation and the fatigue attending exertion in a hot climate, the initial difficulty of clearing the soil is great.

When cleared the soil is fertile, but without constant precaution it quickly relapses into the wild state. Deserted clearings in the tropical forest are overgrown by jungle in a surprisingly short time, and the excessive heat and moisture are demoralising to many temperate plants, which run riot in stem and leaf without maturing root and fruit. The influence on man is equally marked. The enervating climate is unfavourable to steady industry, and the reeking soil breeds many diseases For these and other reasons tropical lands rarely develop high types of civilisation.

In the Polar regions the long cold winters and the protracted darkness make agriculture impossible. Man contrives to exist far beyond the northern limit of cereals, but he is stunted in body and his energies are absorbed in the struggle for existence. On the margin of the Polar region the long summer daylight permits almost continuous growth, and greatly reduces the period between germination and ripening. This gives the cereals a greater Poleward range than would otherwise be the case.

In the temperate lands the seasons are regular. The summers are not too hot or the winters too long and cold for cereals and other useful plants to survive. Thus there is a continuity of effort which ensures progress. The inhabitants of the temperate lands are the most highly endowed physically and mentally, and have founded all the great civilisations of the world.

Climate and Elevation. The relation between temperature and elevation has already been explained. A rise of 300 ft. above sea-level corresponds with a fall of 1° F. in temperature. Climate, as determined by latitude, is thus greatly modified by elevation. Temperate and Polar conditions may exist in tropical lands at a sufficient height. Elevation is sometimes advantageous, and sometimes the reverse. In the Andes many flourishing cities are found several thousand feet above sea-level. Here elevation acts beneficially, affording more favourable conditions than the hot, unhealthy lowlands of the coast. The nearer we go to the equator the higher can human settlement be pushed; the farther we go from the equator the nearer sea-level must man make his home. In tropical lands the existence of highlands may increase the area suitable for settlement, in temperate lands it almost inevitably contracts it. This is well seen in France, where the Central Plateau has a mere sprinkling of inhabitants though the surrounding lowlands are thickly peopled.

Rainfall. The second climatic factor is the distribution of rainfall. Many fertile regions are uninhabited because they are rainless. Such areas are either remote from the sea, the ultimate source of rain, or in the lee of mountains, which intercept the rainy winds, or in the track of dry winds. Some of the drier regions are grass lands, but the most arid are deserts, except where irrigation is possible. Deserts, when irrigated, are often exceptionally fertile, because the chemical constituents from which plants build up their tissues have not been washed out of the soil by rain. A typical area of this kind is the Great Basin of Utah, where irrigation, round Salt Lake City, has converted the desert into a garden.

In some regions the rainfall is excessive. Even in our own country cereals do not do well in the wetter west. The wettest place in the world is the Khasi Hills of Assam, where over 400 in. of rain fall annually. In such regions only very special forms of agriculture are possible.

The Distribution of Rain. Not less important than the total rainfall is the manner of its distribution over the year. In many dry regions a long drought is followed by torrential rains, which are wastefully expended in flooding the watercourses for a few hours, leaving them empty soon after. Regular distribution is necessary, as well as a sufficient total precipitation. This may be either fairly uniform throughout the year, as in our own country, or uniform at certain seasons, as in the Mediterranean, where nearly all the rains fall in winter. In the latter case a different type of agriculture results. The evergreen trees of Southern Europe are fitted to resist the long drought of summer. The dry autumns bring the vine and other fruits to perfection, and count as one of the climatic advantages of the region.

While the average distribution of rainfall has been worked out for the more settled parts of the world, it is liable to fluctuate from year to year. Some years are exceptionally wet, and others exceptionally dry, and these wet and dry years may occur in short or long cycles. Exceptionally wet and dry seasons are both injurious to crops, and the former may cause floods, and consequent loss of life. Of the two, drought is generally the more dangerous to life, especially in the regions where the rainfall is at no time abundant. The failure of the monsoon in the drier parts of agricultural India means famine, in which the loss of life may amount to millions. In the agricultural regions of North America, where wheat is grown for export by a relatively thin population, it results all over the wheat-importing area in the rise of the price of food, and, consequently, of the price of labour and of commodities in general. In the pastoral lands of the New World and Australia it seldom results in the loss of human life, but millions of stock may perish.

The Track of the Winds. The relation of rainfall to continental and oceanic climates has already been explained on page 300. The windward shores of islands and continents receive rain from moisture-laden winds which have crossed the ocean. These winds become drier as they pass inland, and have, therefore, less moisture to precipitate as rain. The interior of all continents is much drier than their marginal areas. A typical continental climate is dry as well as extreme. A typical oceanic climate is humid as well as equable. [See maps, page 295.]

The above results are due to the action of winds, which exercise great influence on climate. Our own islands lie in the track of the westerly winds, which blow strongly all the year round, but especially in winter. The desert of

Sahara lies in the track of the dry trade winds. On a smaller scale, great importance attaches to local winds. The daily land and sea breezes of seaside places are a familiar illustration. Many others might be found. The traveller in Italy dreads equally the tramontana from the Alps, and the sirocco from the desert. The mistral, or cold Alpine wind, of the Rhone valley prevents the cultivation of the orange and lemon, though these ripen in the neighbouring but sheltered Riviera. The chinook winds of the western prairies of North America are warm winds, before which snow disappears as if by magic, enabling the farmer to begin operations much earlier than would otherwise be possible. Similar winds in the Swiss valleys are expressively called snow-eaters. Winds of the same type blow during harvest in New Zealand, and do great damage by shaking the grain from the full ear before it is cut. A spell of such winds may mean the ruin of the harvest. The cold winds from the Mongolian Plateau make the winters of Northern China very severe, and occasionally cause frosts at Shanghai.

The Effect of Mountains. Elevation affects climate in other ways than merely by reducing the temperature. The position of the highlands helps to determine the rainfall of the regions on either side. When moisture-laden winds approach mountains they are deflected upwards, and, becoming cooled, drop part of their moisture as rain, passing on as drier winds. The windward slopes of mountains are therefore much wetter than the leeward. This difference is well illustrated in the western and eastern slopes of the Pennines of our own country. The south-west monsoon strikes the Western Ghats, which are very wet, while the Deccan peninsula above has a deficient rainfall. The same monsoon brings heavy rains to the southern slopes of the Himalayas, while the northern slopes towards Central Asia are arid. Desert areas are often found in the lee of mountains, as in the desert of Central Asia, or of Western North America.

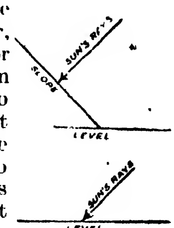
The advantages of a mountainous region, though less obvious than the disadvantages, are not less real. Mountains are the great reservoirs from which rivers are fed. This is specially important in dry regions. In the drier parts of Asia the villages are in the mountain valleys, because there only is water abundant. When mountains are high enough for the formation of snowfields and glaciers, a permanent supply of water in the hot summer months is assured. The glaciers of the Hindu Kush feed the Oxus, which brings life to the deserts of Russian Turkestan. The higher the mountain the steeper and swifter are the mountain streams, and the greater is the load of sediment they carry. Mountains are thus great soil factories, from which rivers obtain the raw materials out of which fertile lowlands are built up. The Abyssinian Highlands have furnished the raw materials of Egypt, the Alps that of the plain of the Po, the Himalayas that of the plains of Bengal. The higher the mountains the more likely is it that extensive and fertile lowlands will be formed at their base.

Rivers rising high have swift currents, which make them useful as sources of power. The sluggish rivers of the English Midlands are almost useless for this purpose, while innumerable Alpine valleys obtain cheap electric power from the torrents that rush down them. Such regions may develop flourishing industries, as in the valleys of the Jura or the Black Forest.

The Treasures of the Mountain. The wet windward slopes of mountains are usually densely forested, and the timber is easily transported by the streams. Equally valuable are the minerals in which most highlands abound. Mountains are formed by the crumpling up of the earth's strata into folds. The upper strata are then gradually worn away and deep valleys cut by the action of weather, ice, or running water, so that the inner strata are exposed. This often brings valuable minerals to the surface. In the Pennines the layers younger than the coal measures have been worn away, exposing rich coalfields on both flanks. In Southern England, where the strata have not been folded and elevated in the same way, the coal measures are buried miles deep and cannot be worked. The silver mines of the Andes, the mineral wealth of the Rockies or the Urals illustrate the importance of minerals in highland regions. One of the most widely distributed useful minerals is building stone which, as in the case of the marbles of the Apennines, or Greece, may be valuable for its beauty.

Mountains are often useful in keeping off hurtful winds. The open plains of North America, which stretch almost unbroken from the Arctic Circle to the Gulf, are often swept by icy Polar gales, and the orange groves of Florida may be ruined by frost. The French and Italian Riviera, on the other hand, are sheltered from cold north and east winds by the Alps and Apennines. Oranges and lemons ripen out of doors and the air is fragrant with flowers. To this fortunate situation is due the prosperity of the innumerable health resorts.

The Influence of Slope. Slope determines the direction of rivers and their commercial value. Those following the short slope tend to be short and swift, those of the long slope to be longer, slower, and better fitted for navigation. This is well seen in the Andes, from which no river of importance flows west into the Pacific, while the great Amazon flows east to the Atlantic. If mountains are centrally situated, great rivers may flow in many directions. From the St. Gotthard Alps the Rhine flows to the North Sea, the Rhone to the Mediterranean and the Ticino to the Adriatic.



Slope is important in another way. The diagram shows that on the slopes facing the sun the sun's rays fall more nearly vertically than on the level, and consequently have a greater heating power. This explains why, in many parts of Central Europe, southern slopes of the hills are terraced with vineyards. In the

Southern Hemisphere the northern slopes are thus planted.

The effect of slope on a large scale is seen in the contrast between valleys opening north and south. Every traveller across the St. Gotthard notes the contrast between the valleys on the Swiss and Italian slopes. In the latter the snow line and tree line are much higher, and the chestnut, mulberry, olive and vine are cultivated to a considerable height.

Finally, as we saw, highlands may be advantageous in tropical lands by lifting large areas above the unhealthy climate of the plain. This is the case in South Africa, where only the highlands above the fever line, which reaches as high as 4,000 ft., can be inhabited by Europeans. A much greater range of products can also be cultivated.

Mountains and Passes. The obstacles to communication presented by mountains are very obvious. To the physical labour of ascent, which narrow precipitous valleys, deep unfordable rivers and dangerous glaciers may render very great, are added, in the case of the higher mountains, the sufferings due to intense cold, high winds, and the difficulty of breathing the highly rarefied air. Mountains frequently form a barrier between two countries, especially when the routes across them are difficult. They hinder commercial intercourse by increasing the time and the cost of transport. The former consideration is so important that costly engineering works, such as tunnels through the Alps, ultimately pay for themselves by the economy of time effected.

The amount of resistance to communication offered by a mountain range depends on the height not of the peaks but of the passes. It matters little how high the peaks on either side rise if the pass or depression between them be low. A second important point is whether a pass can be found which enables the entire system to be crossed. Hence the importance of such Alpine passes as the St. Gotthard and the Brenner. Other things being equal a railway will tend to take a route where a single pass only need be negotiated, as in the transcontinental line from the Argentine into Chile, where the narrowing Andes can be crossed by one pass, the Cumbre or Uspallata.

The command of the passes means the control of the region. For this reason Switzerland fortifies the St. Gotthard, and Britain must retain the control of the Khaibar route from the plains of India into Afghanistan at any cost.

Hardships among the Mountains. Highland regions are, except under exceptional conditions, thinly populated. The lower temperature, and especially the longer and colder winter, are unfavourable to agriculture, and though pasturage may be good in summer the animals must generally be driven to lower, warmer valleys in winter. The heavy rainfall and the erosive force of the mountain streams rapidly denude the slopes of soil, so that for agriculture some form of terracing, always a most laborious process, is generally necessary. Every traveller in the Alps will remember the tiny terraced gardens, banked up with stones, a pathetic witness to the hardship of the mountaineer's life. The terraced olive yards of the Mediterranean represent centuries of unremitting labour. Perhaps the most striking example is seen in the high valleys opening to the upper Oxus or Indus, where bare mountains, stripped of soil, slope precipitously to raging torrents. After every flood the hill folk climb down to the confluence of the nearest side valley to gather up a basketful of soil, out of which they build up terraces of soil on the rocky hillside. In this way little villages win a hard subsistence at great heights among the bleak mountains of Central Asia. But the amount of labour expended is evidently incommensurate with the result, and, though mountain dwellers are generally strong and enduring, they remain a frugal people without those more complex needs which make for progress.

This suggests another reason for mountains acting as barriers. They are infertile and thinly peopled. The Northern Highlands of England were thus, though not high, an effective barrier between England and Scotland till population became dense on the northern coalfields.

The Influence of Rivers. Mountain and river are almost correlative terms, and in considering the influence of mountains we have incidentally considered in part that of rivers. Like that of mountains this influence is mixed, sometimes co-operating with man's efforts, and sometimes thwarting them. The importance of rivers as routes is obvious. A river is ceaselessly at work broadening and levelling its valley [see page 457] Many rivers offer a choice of routes, by water or by land. Others, though not navigable, are practicable as valley routes. Population tends to follow the river valleys, which are the natural roads. Hence, we find civilisation early developing in the river valleys of the Ganges, the Euphrates, the Nile, and so forth.

The importance of the river as a route grows with the development of means of communication. Most of the great land routes of the world follow rivers, though the line has frequently to be blasted out of the sheer sides of the valley.

Rivers, however, hinder communication as well as acilitate it. Many side valleys open to the main valley, and the streams which fill them must be bridged or otherwise crossed. Sometimes the character of the country makes this extremely difficult. The rivers may have cut deep cañons far below the surface of the country, to which descent may be almost impossible. Here a bridge is the only practicable method of communication, and costly bridges are not built till the development of a country is far advanced. In the earlier stages such cañons effectually hinder communication, as in the drier parts of the Western United States. Or, again, a river may be so swollen by floods in summer as to close a route which it opens in winter. This is the case on the great trade route from Leh to Yarkand in Central Asia. The winter route follows the Shyok Valley, but in summer the river comes down in flood, making

the valley impassable. The summer route has to go up many side valleys and across the passes which separate them.

Rivers as Constructive Agents. Rivers are ceaselessly at work making new land [see page 458]. This is sometimes advantageous to man and sometimes the reverse. It has given him some of the most fertile lands in the world, but it may undo his work, and make his task more difficult.

In every flood a river spreads beyond its banks, leaving behind it when it retires a deposit of soil. Thus it gradually levels the land on either side, forming a flood plain. The soil of the flood plain becomes deep and fertile. The flood plain of the upper Rhine, between the Vosges and Black Forest, is one of the garden spots of Europe. On a larger scale the same process builds up vast plains and deltas like those of the Rhine, the Po, or the Nile.

Broadly viewed, therefore, the constructive work of rivers benefits man by creating new lands for his occupation. But immense loss and damage may be caused in the process. The floods of the Hwang-ho constitute China's sorrow, and those of the Mississippi are almost equally destructive. Man may be forced to check the misdirected energy of such rivers by building embankments and otherwise restraining the tendency to flood. The forming of bars and the silting up of harbours are disadvantages which result from the constructive energy of rivers.

The Newer Uses of Rivers. In other ways rivers exercise an important influence on the development of civilisation. Irrigation may be necessary, and the rivers of a country may or may not be suitable for the purpose. If they are, as in the case of the Ganges, the Nile, the Euphrates, and many others, agricultural prosperity is assured. If they are not, as in the case of the Spanish rivers, which are in deep gorges, the development of a country is hindered.

Rivers may confer another advantage on a country by supplying power. The early manufactures of the Tweed or Yorkshire Ouse prospered largely because there were rapid streams to turn the mills. The discovery of electric power has made the command of water power infinitely more valuable. Niagara Falls have long been harnessed in the service of man. The largest producer and transmitter of electric power in the Old World is the Falls of Cauvery in Mysore, with 93 miles of wire to the Kolar Goldfields, and 57 miles to the electric lights of Bangalore. The command of water power may occasionally make mountain regions important industrial centres, but it is usually where the river enters the lowlands, forming falls, that industrial centres develop. This is well seen in the chain of flourishing manufacturing towns along the Appalachian "fall line."

Irrigation plays a great part in the development of many countries. Rivers are not essential, for water may be collected in cisterns and tanks in the wet season, as in Southern India, or obtained by sinking wells to water-bearing strata, as in the Sahara, the Western United States, or Australia. But for irrigation on a great scale rivers are necessary. The usual method is to dam the river, forming a head of water from which distributing canals can be fed. This method is applied with conspicuous success to the Indus, the Ganges and the Nile.

Plateaus and Plains. Plateaus have more or less of the disadvantages of all highland regions according to their elevation. Under certain circumstances they may be the most favoured part of a region. The plateaus of Switzerland, of Central Asia and the Andes are cases in point, though for a different reason. High plateaus are seldom fitted for agriculture, but their dry pastures often produce a fine quality of wool or hair. From that of the sheep and goats fed on the plateaus of Asia Minor and Persia are made Turkey and Persian carpets, the finest and most durable in the world. Plains present great uniformity over considerable areas, and offer the minimum resistance to movement and communication. They may be swampy and low lying, as in Holland, but this is met by draining and dyking. The soil is fertile for the same reason that valley soil is fertile. Throughout the world plains are centres of population, and the site of all the important cities. When they are adjacent to good harbours their prosperity is still more marked.

Soils. The character of the surface soil is important. Clay is stiff, compact and impervious to the free passage of air and water. It is therefore unsuited to agriculture. A sandy soil has the opposite defects, and is too loose and porous. Fresh lava is absolutely unfertile; but, as its surface begins to weather, vegetation appears. When thoroughly disintegrated it is extremely fertile, owing to the presence of chemical substances. Thus, though the slopes of Vesuvius are barren almost to the base, the surrounding district of Campania is extremely rich. In forest regions decaying vegetable matter enriches the soil, forming humus or vegetable mould. The virgin soil of cleared forests is therefore very fertile, as in Siberia or North America. Alluvial soils are generally fertile after they have passed through the initial swampy or waterlogged stage. We have already referred to the fertility of desert soils. The loess region of Northern China is composed of very fine soil carried by the wind from the deserts of Central Asia. An extreme case is seen in the nitrate deserts of Chile, which, though barren of vegetation, yield an invaluable fertiliser.

Certain soils are specially adapted to certain crops. The Deccan has its "cotton soil," and the Black Earth Lands of the Russian Empire grow fine cereals.

Indirectly, too, the character of the soil exercises considerable influence on the conditions of existence by its suitability or unsuitability for making hard-wearing roads. In a clay country the roads are impassable after rain, and impede communication. In the lower regions of China the roads become deeply sunk in the porous soil.

The Land near the Sea. The prosperity of a marginal area depends partly on the character of the coast, and partly on the character of the

back region, or hinderland. Good harbours are of little value where the hinderland is poor, and a rich hinderland may develop slowly owing to the absence of harbours. With good harbours and a good hinderland a marginal area possesses superior advantages to an inland region. Most of the countries of Europe and of Eastern North America are in this favoured position.

Coasts and Harbours. The different types of coasts have already been described. The presence or absence of cliffs, bays, gulfs, and estuaries opening to navigable rivers, the depth or shallowness of the seas off the coasts, the existence of sandbanks, reefs, or sunken rocks, and the presence or absence of islands, all affect the commercial development of a region.

Where mountains rise immediately from the sea good harbours are rare. In the mountainous island of Capri, near Naples, there are only two possible landing-places at any time, and in stormy weather only one. On some mountainous coasts the sea has penetrated far inland up the river valleys, forming rias, fiords, and other inlets. The coasts of such fiords are generally fringed with islands, which form a natural breakwater, as in the Skerry Guard of Norway. The fiords are natural routes to the interior, and as such valuable, but in these regions the interior, or hinderland, is apt to be rugged and barren, neutralising this advantage to a great extent. Examples of fiord coasts with poor hinderlands are Norway, the West Coast of Scotland and British Columbia and of ria coasts in North-west Spain and South-west Ireland. All along the Pacific coast of America good harbours are few. The Atlantic coast of North America, on the other hand, has many good harbours in drowned river valleys which give access to a rich hinderland. The contrast between the prosperity of the eastern and western coasts of North America is very instructive.

Low, sandy shores are also unfavourable to commerce. Such shores are frequently beaten by dangerous surf, as on the coast of West Africa, or Western India, where special surf boats are used for landing.

Seas and Oceans. The distribution of seas and oceans and their influence on climate have already been described. Europe is fortunate in possessing two inland seas, which penetrate far inland—the Baltic-North Sea in the north and the Mediterranean in the south. Both, but particularly the latter, have played a great part in the history of the world by rendering communication easy. The early growth of civilisation and commerce all round the Mediterranean is a case in point. North America has somewhat similar advantages in what we may call the St. Lawrence Sea in the north and the American Mediterranean in the south. Eastern Asia is well cut up by inland seas, but the other continents are very compact.

Trade Winds. Winds have already been described. In his struggle for existence man must take winds, currents and tides into account.

Winds exercise a great influence on navigation. A vessel leaving Southampton for Cape Town is first in the region of the west winds and may have rough weather for a day or two, especially in "the Bay." Towards 30° N. it comes into a region of calms, out of which it passes south into the north-east trades, which blow steadily till the belt of calms round the equator is reached. South of these equatorial calms it enters the region of the south-east trades, and after passing through the calms of Capricorn perhaps experiences rough weather on nearing Cape Town in the region of the southern westerlies. These, it will be remembered, blow much more fiercely in the Southern Hemisphere, giving the "roaring forties" an evil reputation, and making the voyage round Cape Horn in particular an experience to be dreaded. Ships naturally go with the wind so far as possible. A ship sailing west across the Atlantic steers a southerly course to get into the north-east trades, which originally guided Columbus to the New World. Returning eastwards to Liverpool it steers further north, to get into the track of the west winds. The summer and winter courses also differ somewhat, as the track of these winds varies with the season. A sailing vessel to Australia, similarly, finds it easiest to go by the Cape of Good Hope and return by Cape Horn.

Currents and Tides. The influence of currents on climate has already been considered. The warm surface water of the Gulf Stream Drift keeps the ports of Britain and Norway ice-free in winter; but the cold Labrador current closes the St. Lawrence ports in winter. In a less degree than winds, currents influence courses at sea. A vessel going with the equatorial current proceeds much more quickly than one going against it.

Currents play another part, which beautifully illustrates the interdependence of Nature. They often carry seeds, some of which may survive their long exposure to sea-water and germinate. In this way the coconut palm early appears on coral islands, to which its seed has been carried by ocean currents.

Tides in particular are of great assistance to shipping by carrying vessels up and down estuaries into harbour. The high tides of London, where two tidal crests meet, have contributed to its greatness as a port. Some harbours can only be entered at high tide.

Ice. The value of a sea is much lessened if it is ice-bound in winter. The ports of the Baltic and the northern Black Sea are of less importance than the ports of the North Sea and the Mediterranean, which are ice-free. The summer course of Atlantic liners is affected by the presence of icebergs, which are then drifting south from the Polar regions.

Continued

TEXTILE PRINTING

Hand, Block, and Machine Printing. The Perrotine. Cylinder Machines. Multiple Colour Printing. Finishing Processes

By W. S. MURPHY

Preparation. Cotton, wool, and silk in the order named are the fibres most frequently dealt with by the textile printer. Cotton and wool are printed not only in the piece but as yarn to produce variegated effects in cloth, and woollen slubbing is also printed. The preparatory processes do not differ greatly from those which precede dyeing, and may be studied in the Dyeing section of our course. Silk is well scoured, calico ordinarily is bleached, not only to avoid interference with the brilliance of the colours, but to give good whites when these form part of the pattern. The textile printer is contented, however, with a less perfect bleach than the "market bleach" given to goods intended to be sold in the white state. Wool is chlorinated—that is, treated with a weak solution of bleaching powder or of a hypochlorite. This greatly reduces the felting power of the wool, and makes the fibre more easily penetrable by liquid.

Block, or Hand Printing. It need hardly be said that block printing was the first method practised in this trade. The logical progress of textile printing, in fact, has been that of typography, from hand printing to machine printing on the flat, and from that to rotary printing. Block printing is still largely used for silk, and it is comparatively recently that machine printing has been adapted to the treatment of this fibre.

Blocks. The blocks are usually made of peartree wood or some other hard timber, and are of considerable thickness. On the face of the block the design is cut out in relief or formed by copper wire. When the design is a simple repetition of a pattern, it is usual to make the block large enough to contain the whole pattern. If the design be large and complicated, it may be divided into sections, each block carrying a section, and the whole making a set. Designs of two or more colours require as many blocks as there are colours, unless, as often happens, the combination of two colours produce a third. Many designs printed on heavy cloths, such as felt carpets, are vari-coloured in such a way that each colour stands out separate from its fellow. The printer's colour is a kind of paste. In old-fashioned works the paste is laid on to the block with a palette knife; but other and better means are now generally used. A woollen cloth is stretched tightly over a hoop, and upon it the colour is spread. To give the surface of the *sieve*, as it is named, more elasticity, it is floated on paste or size in a tub. On this sieve the block is pressed, and receives its coat of colour. The appliance for vari-coloured blocks to which we have referred, consists of a wooden block, hollowed out in parts the same size and position at the pattern of the printing block. Into these hollows the different colours are laid, and the woollen cloth stretched over all. Between each colour compartment pieces of thick cord are glued, to prevent one colour from running into another on the cloth. When the printer presses his block on the cloth, the different colours come into place.

The Table. A textile printer's table must be very smooth and true. The bed of the table is generally made up of slate slabs. At each end of the table strong brackets are fixed, and upon the one is slung the cloth beam, while on the other the taking-on beam is hung.

Printing. The printer draws a length of the cloth on to the table, and carefully smooths it down to the bed, till not a vestige of wrinkle remains. Having charged his block with colour, he lays it face downward on the cloth, and gives it a tap with his hand, or in the case of large patterns, with a mallet. After a moment, the block is lifted, and a clear impression of the pattern is left on the cloth. No matter what the character or length of the design may be, the printing action is the same. Block printing is merely a repetition of these simple actions in perfect register.

Machine Printing. For the present, we defer examining the further treatment of hand-printed goods, because the finishing operations of all printed cloths are the same, whether printed by machine or hand blocks. Confining ourselves to the means and methods of putting on the impressions meanwhile, we note that textile printing machines are divided into two classes. The one class is the block printing machines, and the other is the cylinder printing machines.

The Flat Press. The first step towards the introduction of machinery was an English invention that imitated copper-plate printing, calico being substituted for paper. It was practically confined to one-colour printing, and we believe that this method is no longer practised.

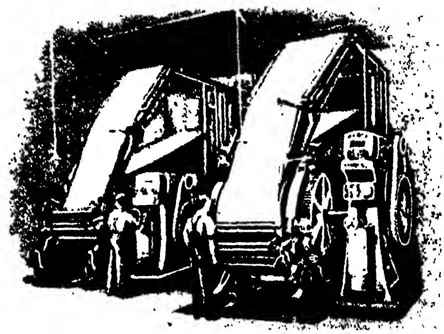
The Perrotine. A block printing machine, capable of working in three colours, was the next step. It is very largely used in Alsace and Belgium. This machine has never made much headway with British printers, though some of the highest-class houses use it alongside the cylinder machines. The perrotine is a very intricate piece of mechanism, and requires very careful and detailed study.

The machine is contained within a strong framework, semicircular in form, the fore end of the circle being continued in a curved line up, to hold the rollers which carry the blanket and cloth to be printed. The simplest perrotine prints three colours, and therefore has three blocks,

three printing tables, and three sets of colour rollers, with apparatus for colour supply. This, to begin with, suggests complexity. Our attention should first be directed to the printing blocks and their accessories. The machine has three equal arms joining at the centre, and therefore at right angles to each other. On all these arms we find a block holder into which the engraved block is fixed. Each holder is screwed on to a sliding piece keyed to a pair of beams moved alternately backward and forward by shafts supported on the main arm. The three blocks are thus given a to-and-fro motion, forward to print the cloth, and back to let it pass. Having found our blocks, we have next to find out how they are supplied with coats of colour. At the side of each arm, supported on levers, are three colour-boxes, furnished with rollers. One roller revolves in the colour-box and one runs in contact with but above its fellow, taking on a supply of colour from it. Screws regulate the relations of the rollers, bringing them into close contact when much colour is desired, and separating them if the colour supply should be light. Neither roller, however, ever touches the printing block. The medium between block and colour roller is a sieve ingeniously controlled by rods extending from a lever beam. The sieve is on the end of the rod, and the timing of its action shows fine adjustment.

We have been working from the outside into the machine, and now we are at the very centre. Here is the table upon which the block impresses the cloth. There are, of course, three tables. For the sake of simplicity we have confined attention to one set of appliances; but the tables cannot be appreciated unless the three are seen. Three iron bars of equal size are joined at right angles to each other, and on the heads of the bars sit the smooth tables. The whole three are cast as one piece, but we separate them to understand the real character of each. A table faces every block. At the four corners of the table frame sit four rollers. The tables, being flat, have no power to act on the cloth; but these rollers carry the cloth to be printed over the tables, their surfaces being covered with little teeth to hold on to the fabric. Next, above the first of the rollers we find a large roller upon which the blanket, back cloth, and pieces to be printed join together. Up above and near to the front part of the machine are sets of tension rollers and carrying blocks. Outside of all sit the beams from which come the three fabrics mentioned.

Working the Perrotine. Wound on to a suitable roller, the cloth is hung on the brackets in front of the machine. Up above, the endless blanket and the back cloth are similarly adjusted. Into the colour-boxes the printer lays his colours, adjusts the screws which regulate the supply, and puts the doctor knives over the colour rollers to clear off superfluous pigment before the sieves come into contact. The blocks are firmly screwed into the holders. On the end of the piece a few yards of rough cloth are joined and this is drawn into the machine. When everything has been put into position, the perrotine is started. Blanket, back cloth, and printing piece pass in on their separate ways, and join at the central roller above the table rollers. As the three fabrics come together the blanket is uppermost, but when going round this roller the positions become reversed, and the piece



208. BLOCK PRINTING MACHINE
(Mather & Platt, Ltd., Manchester)

cloth is uppermost when they pass on to the first table roller. Thrust in by the lever-controlled rod, the sieve has taken its coating from the colour roller and transferred it on to the block coming forward. Table and block now press in contact, with the cloths between them. The first colour has been printed. The cloths next pass round the second corner rollers, and the machine again prints. A third time the operation is performed, and then the piece cloth returns to the outer world a printed cloth, to pass on to the drying rollers.

Improvements. The original perrotine has been greatly modified and improved during the past twenty years. But the principles on which it works are unaltered, and we have purposely selected the first form of the machine because it exhibits, even more clearly than the later developments, the essential characteristics of a block printing machine. Improvements have chiefly taken the direction of adding to the number of colours which can be perfected at once on the machine. Some of the newer perrotines print twelve colours at once with great speed, and twenty colours are occasionally obtained in one printing. The English block printing machine, which is illustrated [208], gives a good idea of the size and character of that class of machines.

Cylinder Machines. The idea of devising a roller to perform the same service as a flat surface has been at the root of many of our finest mechanical inventions. Application of that principle to textile printing has gone to great lengths. Cylinder printing machines for textiles were invented by Bell, a Scotchman, in 1785.

Single Cylinder. This is a simple structure. In the middle of the machine is the

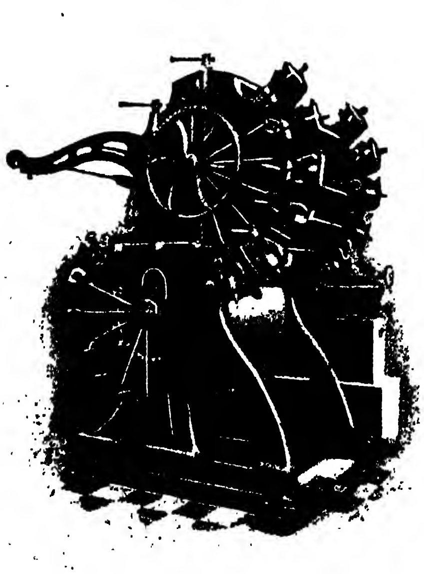
wide cylinder, called the pressure cylinder or bowl. Under it we see the pattern roller, with slanting knives at each side of it. Further below sits the colour roller in the colour trough. Note these parts a little more closely. The roller in the colour trough is clad with soft, thick woollen cloth, which enables it to take up the colour. The pattern roller runs in direct contact with the colour roller, and thus receives the necessary supply of colour. The knife at the inner side of the pattern roller is called the *colour doctor*, because it clears away all the superfluous colour; the knife at the other side is named the *lint doctor*, its function being to take away any threads which may have been deposited by the cloth on the pattern roller in passing. Made of cast iron, the large pressure cylinder is heavily clad with smooth felt to give a finely smooth and elastic surface. The cloth apparatus is equally simple. Up on the front of the machine the cloth beam is hung; adjoining hangs the blanket roller, and underneath sits the guide roller which joins them. Cloth and blanket go down round the pressure cylinder into contact with the pattern roller, and round up to the delivery rollers on the other side.

The vast saving of labour and the greatly accelerated production effected by the adoption of the cylinder principle is here worthy of note. Thousands of yards of cloth can be printed on this machine in a day.

Three-colour Machine. Progress from the single-colour machine to the three-colour printing was easy to our ingenious mechanics. We say ingenious because some difficult problems are involved. The idea of placing pattern rollers, with doctors and colour apparatus, on the sides of the pressure cylinder was obvious; but the problem of driving these appliances could hardly be described as very simple. Moreover, there remained the question of distributing the pressure on the added rollers. These difficulties have been met in various ways by different inventors. The simplest and most obvious method—namely, that of strengthening and enlarging the framing, and giving the second and third roller the same gearing as the first, has been adopted in many machines with success. In other machines the principles of the perrotine have been adopted.

Printing Many Colours. Every colour must have its own separate pattern roller, knife doctors, and colour-boxes with rollers. To group these round the pressure cylinder in proper positions has been the work of the machinist. How this has been accomplished we see most clearly in a machine designed to print four colours. The pressure cylinder is 6 ft. in circumference, and sits in the centre of the machine. The gudgeons of the cylinder rest on bushes, which can be moved up or down in slots in the side cheeks, strong screws from the top of the frame fixing them in position. Round the cylinder are grouped four mandrels, slotted, and fixed in strong bearings on slide pieces. On to these mandrils the engraved pattern rollers are forced by means of a screw press. By this arrangement the changes of pattern and colour can be effected by merely changing the pattern roller. Colour-box, roller, and doctors are contained within the slide piece, secured to the framing by means of a double screw. A pair of arms, jointed to the inner screw of the slide pieces and strengthened by bolts from the machine frame, bring forward the pattern rollers to the pressure cylinder. The mechanism of all four rollers—each with its equipment of colour-box, colour roller, doctors, and controlling levers—is practically similar. From the head of the frame two long arms curve out, and between these rests the cloth beam; while from beams more directly over the pressure cylinder come the blanket and back cloth. The cloths meet on a roller just above the cylinder, and come down into the machine. A double cylinder machine [209] prints twice the number of colours on the same principle.

Mordants and Dyestuffs. These will be considered in detail in the Dyeing section of this course. It is rather the methods of application that vary in dyeing and printing than the mordants and dyestuffs employed, although some dyes are more suitable for dyeing than printing, and vice versâ. Both soluble dyes and insoluble colours (pigments) can be used in printing. The pigments are usually coloured minerals in fine powder—ultramarine, for instance—and are mechanically fixed on the cloth with albumen. The natural colouring matters, especially logwood and indigo, are largely used, and any class of artificial dyestuff may be employed. As, however, in printing, the



209. DOUBLE CYLINDER PRINTING MACHINE (Mather & Platt, Ltd., Manchester)

fibre is not dyed so thoroughly, and as the first necessity of prints is fastness to light, the mordant colours—the alizarines, for instance—are more largely employed than the colours which require no mordant.

Styles of Work. The printer can ring an enormous number of changes in his methods of doing things, and he can combine dyeing very effectively with printing. For instance, everyone is familiar with the old pattern of indigo blue scarf with round white spots. This was produced by printing a *resist* or *reserve* paste on the cloth and then dyeing it in the indigo vat. The places covered by the resist were protected from the action of the vat and consequently remained white. Or the printer may reverse this process; he may dye the cloth first and print on a *discharge* This has the same effect of leaving a white pattern on a coloured ground, and, by adding to the discharge colouring matters not acted upon by the chemical agent that destroys the body colour of the cloth, he can produce a *colour discharge*—that is to say, for instance, red upon a blue ground. Again, as in one of the oldest *styles*, known as the *dyed* or *madder* style, he may print a mordant on to the cloth, dyeing the cloth subsequently with a colouring matter which will not go on to the fibre except in the parts impregnated with the mordant. The result is a pattern on a white ground. The term "madder style" is used because this method was employed for madder long before the introduction of the artificial colouring matters. Now madder has gone entirely out of use—in calico printing, at any rate--and alizarine reigns in its stead; but this style is still employed for alizarines and other colouring matters. Again, the printer may print the colour paste on to the mordanted cloth, or the mordant may form a part of the printing colour. As it is evident that the printer may combine these and other styles, it will be seen that he has an armoury of resources.

Padding. The large firms of indigo dyers were all printers to the extent of producing patterns on their goods by means of printed reserves in the manner we have instanced. The printer, however, is frequently content with a speedier form of dyeing known as *padding*. The fibre is not so thoroughly impregnated as in vat or beck dying, but the method is practically confined to calico, and for this material it is advantageous. It will be readily understood that the smaller amount of colour, or lesser impregnation of the fibre, allows better discharge effects to be obtained. In other words, it is easier to get good sharply outlined patterns by printing a discharge, whether white or coloured, on padded than on dyed material, and this applies even more particularly to *slop padding*, which will be touched on later.

The Padding Machine. This is a very simple apparatus. It consists essentially of a rather small vessel in which a concentrated solution of the mordant or dyestuff is contained, guide rollers within the vessel, by means of which the cloth is run through the liquor, and squeezing rollers directly over the dye bath, by which the surplus liquor is squeezed out into the dye bath. Attached to the frame of the machine are rollers to receive and deliver the cloth. The necessary concentration of the bath for this rapid form of dyeing must be noted. It emphasises the fact that in apparatus dyeing generally, where *short* baths have to be used, the dyestuff must be very soluble.

Slop Padding. When the colour is applied uniformly to one side of the cloth only, the process is termed *slop padding*. This is used principally for light, easily discharged shades. A single-colour printing machine is ordinarily employed. The printing roller is plain—that is, no pattern is engraved upon it, but the surface is grooved with fine lines in order to take up the colour. A felt-covered wooden roller, revolving in the concentrated dye bath, in touch with the printing roller, transfers the colour or mordant to this latter. Over the printing roller, and in touch with it, is a large iron roller, which brings the cloth into contact with the printing roller. The printing roller is provided with the usual colour-doctor, and in order to give an elastic print'ng surface, a thick band of felt, known as the *blanket*, revolves in an endless band between the iron roller and the cloth. As a rule, there is a *back cloth* between the cloth and the blanket to prevent the felt from being soiled.

Machine Printing. It must be noted here that although the mechanical arrangement of a machine to print a large number of colours makes it appear complicated, an eighteen-colour machine is merely a multiplication of the essential parts of the one colour machine described above. Whether it be for cotton, woollen, or silk, the actual apparatus is a copper roller engraved in lines or dots, with a pattern, one printing roller being provided for each colour. The main difficulty is to make the colours register properly —that is, to fall into their proper position in the pattern, and this, of course, increases in proportion to the number of colours in the pattern. Each roller must be in its correct position on the mandrels, and all the rollers must be correct in relation one with the other. The edge of the doctor must be perfectly level, and press evenly against the whole length of the roller. Many other difficulties crop up, but each suggests its appropriate remedy.

Printing Woollen - slubbing and Cotton Yarn. Unspun wool in the form of slubbing is printed with stripes in order to produce fancy yarns, and cotton yarns, usually in the form of warps, are printed in order to produce variegated cloths. The printing machine already described is used with a number of rollers corresponding to the required number of colours As a rule, the printing roller is simply grooved, in order to print the yarn in stripes. The doctor is arranged so that it clears off all the colour, except that in the grooves, before the printing roller comes into contact with the stuff. Especially for slubbing, the blanket must be softer than usual, in order to allow the stuff to be pressed into the groove, and so to take up the colour.

Continued

Continued from page 4368

ITALIAN

Continued from page 4360

By Francesco de Feo

INTRANSITIVE VERBS

When the action or fact expressed by the verb is completed without an object (I walk, *io cammino*; I sleep, *io dormo*) the verb is intransitive. Intransitive verbs, as a rule, are conjugated with the auxiliary *èssere* (Example: *É accaduto*, it has happened); but some are conjugated with *avére* (Example: *ho viaggiato*, I have travelled), or admit both auxiliaries (Example: *sono vissuto* or *ho vissuto*, I have lived).

The only rule that can be given as to which auxiliary should be used is that the verbs expressing an action are conjugated with *avère*, and those expressing a fact with *èssere*. Exceptions to this rule are to be learnt by practice.

EXERCISE XXXV.

1. Quando sono entrato essi èrano già partiti. 2. Sono contento che siate riuscito in questo affare. 3. Lo spettàcolo è durato più di due ore. 4. Son caduto e mi son fatto male. 5. Non ho sonno; ho dormito tutto il giorno. 6. Aspetto mio fratello; doveva venire col treno delle sette, e mi maraviglio che non sia ancora arrivato. 7. Se foste venuto dieci minuti prima vi sareste incontrato col signor N. 8. Una nave da guerra è affondata nel Bàltico. 9. Una torpediniera giapponese ha affondato due navi russe. 10. Ho girato tutto il giorno senza conchiùder niente.

DEMONSTRATIVE PRONOUNS

The demonstrative pronouns are:

questi (*koo-èhstee*), this one
quegli (*koo-èh-'lee*), that one
costui (*costoò-ee*), this one (here)
costei (*costèh-ee*), this one (here)
colui (*coloò-ee*), that one (there)
colei (*colèh-ee*), that one (there)
un tale (*oon-tàhleh*), such a one
ciò (*chee-ò*), that
ne (*neh*), of it, of him, of them, etc.
ci (*chee*), in it, on it, with it, etc.

1. *Questi* and *quegli* are singular, and are only used in speaking of persons; but modern usage prefers the demonstrative adjectives *questo* and *quello* used substantively.

2. *Costui, costei* (plural *costoro*, for both genders), and *colui, colei* (plural *coloro*, for both genders) are used only in speaking of persons, and in familiar language nearly always imply a shade of contempt. Examples: *Io non mi fido di colui*, I do not trust that man (the fellow). *Non prestate danaro a costoro*, Do not lend money to these men.

3. *Colui che, colei che, coloro che, quelli che, colui il quale*, etc., are rendered in English by he who, she who, they who.

4. *Ciò* is singular and means "this thing." *Ne* and *ci* may be considered as demonstrative pronouns, as in many expressions they take the place of *ciò*. Examples: *Non ne* (*di ciò*) *capisco niente*, I understand nothing of that. *Che ne pensi?* (*che pensi di ciò?*), What do you think of that? *Non ci riesco* (*non riesco in ciò*), I do not succeed in doing that.

NOTE. The student acquainted with French should compare the use of *en* and *y*.

EXERCISE XXXVI.

1. Mettèteli da parte; ce ne serviremo quando ne avremo bisogno. 2. Ciò non sta bene. 3. Costui è tanto pieno di sè, che pare che tutto il mondo gli appartenga. 4. Questi è uno scrittore di gran mèrito, quegli un poeta genialissimo. 5. Non oso parlare apertamente, perchè temo di èssere malinteso da questi e combattuto da quelli. 6. Voi non sapete quello che dite. 7. Non so come andranno a finire le cose, per me non ci vedo chiaro in questa faccenda. 8. Ecco due bottiglie abbastanza grandi, in questa ci metteremo il vino, in quella l'acqua. 9. Non mi parlate di coloro, essi non mèritano più di èssere aiutati. 10. Ludovico mirava piuttosto a scansare i colpi e a disarmare il nemico, che ad ucciderlo, ma questo voleva la morte di lui ad ogni costo (m.). 11. Colei parla solo per invidia, è mèglio non ascoltarla. 12. Quelli che grìdano di più hanno sempre ragione a questo mondo. 13. Il prèmio sarà dato a quello che l'avrà meritato.

IRREGULAR VERBS

Second Conjugation

Verbs in **ére** (long)—continued

Dolére, to ache

Ind. Pres.-*Dolgo, duoli, duole, dogliamo, dolete, dòlgono.*

Past Def.—Dolsi, dolesti, dolse, dolemmo, doleste, dòlsero.

Future.—Dorrò, dorrai, dorrà, dorremo, etc.

Imperat.—Duoli, dolga, dogliamo, dolete, dòlgano.

Subj. Pres.—*Dolga*, etc.; *dogliamo, dogliate dòlgano.*

Condit.—*Dorrei, dorresti, dorrebbe*, etc.

Past Part.—Doluto.

Parére, to seem

Ind. Pres.—Paio, pari, pare, paiamo, parete, pàiono.

Past Def.—Parvi, paresti, parve, paremmo, pareste, pàrvero.

Future.—Parrò, parrai, parrà, etc.

Imperat.—Pari, paia, paiamo, parete, pàiano.

Subj. Pres.—Paia, etc.; *paiamo, paiate, pàiano.*

Condit.—Parrei, parresti, etc.
Past Part.—Parso.

This verb is mostly used impersonally: *mi pare, mi parve, mi è parso,* etc.

Solére, to be accustomed

Ind. Pres.—Sòglio, suoli, suole, sogliamo, solete, sògliono.
Imperf.—Solevo, solevi, etc.
Past Def.—Solei, solesti, etc.
Subj. Pres.—Soglia, etc ; *sogliamo, sogliate, sògliano.*
Subj. Imperf.—Solessi, etc.
Past Part.—Sòlito.

This verb is very little used, except in the past participle (*sòlito*), which is very common. The expression *esser sòlito* is used instead.

Avére, to have

See pages 2193, 2484.

Calére, to care for, to matter

This verb has only the 3rd persons.
Ind. Pres.—Cale.
Past Def.—Calse.
Subj. Pres.—Càglia.

Capére, to hold

This verb is obsolete; the verb *capire* is used instead. But the forms *cape* and *capa* take the place of *capisce* and *capisca.*

NOTE. Besides the verbs given above, there are only two other verbs in *ére* (long)—*viz.*, *temére,* to fear, and *godére,* to enjoy, both of which are regular.

EXERCISE XXXVII.

1. Godo di vedére che sta bene. 2. Non mi ricordo di lei, ma mi pare di averla veduta in qualche posto. 3. Ebbi il piacére di conòscerla a Roma due anni fa. 4. In campagna siamo sòliti di fare una lunga passeggiata prima di colazione. 5. Non temete di niente, penserò io al vostro avvenire. 6. Mi duole di dovervi parlare in questo modo. 7. Mi duole la testa; sarà mèglio ch'io rimanga in casa. 8. Mi era parso che avèssero suonato il campanello. 9. Finora si è fatto sempre come avete voluto voi, ora mi pare che anche voi possiate fare come vogliamo noi.

INDEFINITE PRONOUNS

The indefinite pronouns are:

altri (*àhltree*), somebody else, any other man,
altrui (*altroò-ee*), of others, to others,
niente, nulla (*nee-èhnteh, noòllah*), nothing, and the compounds of the adjective *uno* used as a substantive:
ognuno (*onee-oòno*), every one.
qualcuno, qualchedùno (*koo-àhlkoòno, koo-àhl-keh-doòno*), some one.
certuno (*chehr-toòno*), a certain person.

1. *Altri* is singular and is used of persons alone: *Làscia che altri parli di questo,* Let some-one else speak of this.

2. *Altrui* is never used as subject, and means only (1) *di altri* (other people's), as we have already seen when speaking of the possessive adjectives, and (2) *ad altri* (to other people). Example: *Non tenère per te quello che è dovuto altrui,* Do not keep for thyself what is due to others.

3. *Niente* and *nulla* are real substantives: *niente per niente,* nothing for nothing; *il nulla,* nothing.

4. We may consider such expressions as the following to be indefinite pronouns: *Dio sa che,* God knows what. *Chi sa chi,* Who knows who, etc.

NOTE. When *niente, nulla,* and the negative adjectives *nessuno, niuno,* etc., come after the verb, the verb must be preceded by the negative *non*; but when they are placed before the verb the *non* is not employed. Example: *Non c'era nessuno* or *nessuno era là,* No one was there.

EXERCISE XXXVIII.

1. Quel pover' uomo ha dovuto mèttere insieme una bella sommetta, perchè ognuno gli ha dato qualche cosa. 2. Io parlo in generale e non vorrei che altri considerasse le mie parole come dirette a lui. 3. L'iniquità si fonda spesso sulla credulità e bontà altrui. 4. Agite sempre correttamente e non vi curate di quello che altri possa pensare di voi. 5. Bussate ancòra; qualcuno dev' èssere in casa, perchè c' è lume nelle stanze disopra. 6. Certuni pare che gòdano delle sventure altrui. 7. Se non mi raccontate tutto per filo e per segno (exactly), non ne faremo nulla. 8. Dite sempre la verità se volete che altri vi stimi. 9. Coloro che non possèggono nulla sono sempre i più generosi. 10. Niente è inùtile, ogni cosa ha la sua ragion d'èssere.

Possessive Pronouns. The possessive pronouns are possessive adjectives used substantively. [See pages 2770-1.]

ESERCIZIO DI LETTURA

Lo svegliarsi la prima notte in càrcere[1] è cosa orrenda! Possìbile! possìbile! Io qui? E non è ora un sogno[2] il mio? Ieri dunque mi arrestàrono? Ieri mi fècero quel lungo interrogatòrio[3], che domani, e chi sa fin quando dovrà continuare? Ier sera, prima di addormentarmi, io piansi tanto, pensando ai miei genitori! Il riposo, il perfetto silènzio, il breve sonno che aveva ristorato le mie forze mentali, sembràvano avère centuplicato in me la potenza del dolore. In quell' assenza totale di distrazioni, l'affanno di tutti i miei cari, ed in particolare[4] del padre e della madre, mi si pingeva nella fantasia con una forza incredìbile. In quest' istante[5], mi dicevo, dòrmono ancòra tranquilli, o vègliano pensando forse con dolcezza a me, non punto presaghi del luogo dove io sono! Oh, felici, se Dio li togliesse[6] dal mondo prima che giunga loro la notìzia della mia sventura! Chi darà loro la forza di sostenère questo colpo? Una voce interna pareva rispòndermi: Colui che tutti gli afflitti invòcano ad àmano e sèntono in sè stessi. Colui che dava la forza a una madre di seguire il figlio al Golgota e di stare sotto la sua croce. L'Amico degli infelici, l'Amico dei mortali!

Quello fu il primo momento che la religione trionfò nel mio cuore; ed all' amor filiale[8] devo questo benefìzio. (Silvio Pèllico, "Le Mie Prigioni.")

NOTES. 1. Prison. 2. Dream. 3. Examination. 4. Especially. 5. At this moment. 6. To remove. 7. Cross. 8. Filial love.

CONVERSAZIONE

È venuto nessuno durante la mia assenza?

Sono venuti due signori, ma non hanno lasciato i loro nomi.

Chi ha i biglietti?

Ecco il mio e quello di mio fratello.

Quale bagàglio volete?

Quello del mio sòcio, perchè è più grande.

Son venuto per dirle addio, perchè parto stasera, e chi sa quando ci rivedremo.

L'accompagnerò alla stazione.

Spero che il mare sia calmo, perchè soffro molto quando il mare è agitato.

Vuol mangiare qualche cosa?

Sì, se c' è tempo.

Le chiedo scusa, signore, non l'avevo vista.

Va anche lei a Milano?

Tanto mèglio, faremo il viàggio insieme.

IMPERSONAL VERBS

The verbs that do not admit a personal subject are called impersonal.

1. Some relate to atmospheric phenomena, and are only used in the third person singular, in the infinitive, gerund, and past participle, as:

albèggia (*ahlbèh-dgee-ah*), it dawns
annotta (*ahnnòttah*), it becomes night
piove (*pee-òveh*), it rains
lampèggia (*lahmpèh-dgee-ah*), it lightens
tuona (*too-ònah*), it thunders
nèvica (*nèhveecah*), it snows
gràndina (*gràhndeenah*), it hails
gela (*dgèhlah*), it freezes

2. Many impersonal expressions are formed with the verbs *fare*, *èssere*, *andare*, *valére*, as:

fa caldo, it is hot
fa freddo, it is cold
c'è nèbbia, it is foggy
è mèglio, it is better
è giusto, it is correct
va bene, things go well
va male, things go badly
vale la pena, it is worth while

3. Other impersonal verbs have as subject an infinitive, with or without preposition, or a whole clause beginning with *che* (that), and with the verb in the *subjunctive*. These are verbs expressing:

a. Necessity, convenience, chance, as:

accade (*ahccàhdeh*), it happens
bisogna (*beesònee-ah*), it is necessary
conviene (*convee-èhneh*), it is suitable
importa (*eempòrtah*), it is of consequence
preme (*prèhmeh*), it is urgent
basta (*bàhstah*), it is enough
tocca a me, *a te*, etc., it is my, your turn

b. Appearance, satisfaction, and other sentiments, as:

pare (*pàhreh*), it seems
sembra (*sèhmbrah*), it appears
risulta (*reesoòl-tah*), it results
piace (*peeàh-cheh*), it pleases
rincresce (*reencrèh-sheh*), one is sorry
etc. etc.

4. Some of these verbs are also used personally, as: *Egli sembra ammalato*, He looks ill; *Sembra ch'egli sia ammalato*, It seems that he is ill.

5. Other verbs have a different meaning in the two constructions, as:

Egli importa vino, He imports wine.
Importa di studiare, It is of consequence to study.
Egli conviene con me, He agrees with me.
Conviene parlare, It is suitable to speak.

6. Other impersonal expressions are active or intransitive verbs used in the reflexive form, as:

si vede, one sees; *si è*, one is;
si vive, one lives; etc., etc.

7. Impersonal verbs are conjugated with the auxiliary *èssere*. A few, however, take *avére*. Those relating to atmospheric conditions may be conjugated with both *èssere* and *avére*: *è piovuto* and *ha piovuto*.

EXERCISE XXXIX.

1. In quel paese nèvica molto raramente, ma piove sempre. 2. Piove a dirotto; bisogna prèndere una carrozza. 3. Bisognerà partire di buon'ora, se vogliamo arrivare in tempo. 4. Ha grandinato e piovuto tutta la notte. 5. Non tuona più, ma lampèggia ancòra. 6. È meglio non uscire oggi; c' è molta nèbbia. 7. Andiamo; non vale la pena di star qui a parlare di cose inùtili. 8. Il tuo amico sembra molto contento; avrà fatto buoni affari in borsa. 9. Sembra ch'egli sia contento, ma veramente non è così. 10. La Rùssia ha importato una gran quantità di grano quest'anno. 11. Importa decìdersi sùbito, perchè non v'è tempo da pèrdere. 12. Lei ha già parlato abbastanza, ora tocca a me. 13. Rincresce il vedére dei giòvani così indolenti. 14. Si deve anche godére un poco in questa vita; si vive una volta soltanto.

KEY TO EXERCISE XXXIII.

1. Dress yourself quickly, because we must go away (from here). 2. Did you enjoy yourself at the theatre last night? 3. Do not approach too near the cage. 4. I begin to be tired; let us stop a little. 5. If you wish to wash your hands, I will give you some hot water. 6. The gentlemen of the second floor have complained about the service. 7. Wake me at half-past seven to-morrow. 8. At what time do you usually get up? 9. Get up; it is very late. 10. Do you remember that lady who was with us in the country last summer? 11. I remember her quite well. 12. One must never lose one's courage in misfortune. 13. Sit down, madam, and tell me everything; you know that you can rely on me. 14. Listen to me, sir, and may Heaven forbid that a day should come in which you will repent of not having listened to me.

KEY TO EXERCISE XXXIV.

1. This picture is worth nothing. 2. Be silent, your words are not worth listening to. 3. I will be silent at once, but it is certain that you will never persuade me to do what I do not like to do. 4. I was so sorry that you did not remain with us the other evening. 5. He fell, but he did not hurt himself. 6. Do not go so soon; stay a little longer. 7. I cannot give more; here is all I have. 8. We know how much your promises are worth. 9. I persuaded him to accept the employment which was offered to him. 10. If you do not like this room, I will give you another.

Continued

FRENCH

Continued from page 4363

By Louis A. Barbé, B.A.

IRREGULAR VERBS—continued

Fourth Conjugation. 1. BATTRE, to beat, *battant, battu, je bats, tu bats, il bat, je battis.* The reflexive verb *se battre* means "to fight." The verbs conjugated like *battre* are *abattre*, to knock down, fell; *se battre*, to fight; *combattre*, to combat; *débattre*, to debate; *se débattre*, to struggle; *rabattre*, to pull down, to lower (the price).

2. CONCLURE, to conclude, *concluant, conclu, je conclus, tu conclus, il conclut, je conclus.*

3. CONDUIRE, to lead, *conduisant, conduit, je conduis, tu conduis, il conduit, je conduisis.*

A number of verbs in UIRE are conjugated in the same way. The most common of them are *construire*, to construct; *cuire*, to cook, bake; *instruire*, to instruct; *réduire*, to reduce; and *traduire*, to translate.

4. CONNAÎTRE, to know, to be acquainted with, *connaissant, connu, je connais, tu connais, il connaît, je connus.*

The "*i*" of the stem retains the circumflex accent wherever it is followed by "*t*." Other verbs conjugated in the same way are *paraître*, to appear, seem; *apparaître*, to appear, *comparaître*, to appear (before a tribunal, etc.), *disparaître*, to disappear; *reparaître*, to reappear; *reconnaître*, to recognise.

5. CONFIRE, to pickle, preserve, *confisant, confit, je confis, tu confis, il confit, je confis.*

6. COUDRE, to sew, *cousant, cousu, je couds, tu couds, il coud, je cousis.*

7. CROIRE, to believe, *croyant, cru, je crois, tu crois, il croit, je crus.*

8. CROÎTRE, to grow, *croissant, crû, je croîs, tu croîs, il croît, je crûs.* In this verb there is a circumflex accent not only over "*i*" when it is followed by "*t*," but over "*i*" and "*u*" in all the forms that would otherwise be identical with those of *croire*.

9. ÉCRIRE, to write, *écrivant, écrit, j'écris, tu écris, il écrit, j'écrivis.*

All derivatives are conjugated in the same manner. Those in most frequent use are *décrire*, to describe; *inscrire*, to inscribe; *proscrire*, to proscribe; *souscrire*, to subscribe; and *transcrire* to transcribe.

10. JOINDRE, to join, *joignant, joint, je joins, tu joins, il joint, je joignis.*

All verbs of which the infinitive ends in *aindre*, *eindre*, or *oindre*, are conjugated like this. The following are some of them: *contraindre*, to constrain; *ceindre*, to gird; *feindre*, to feign; *atteindre*, to reach; *teindre*, to dye; *enfreindre*, to infringe; *peindre*, to paint; *rejoindre*, to overtake; *oindre*, to anoint; and the reflexive verb *se plaindre*, to complain.

11. LIRE, to read, *lisant, lu, je lis, tu lis, il lit, je lus.*

12. METTRE, to put, put on, *mettant, mis, je mets, tu mets, il met, je mis.*

The numerous derivatives of this verb follow the same conjugation. Amongst them are: *admettre*, to admit; *commettre*, to commit; *compromettre*, to compromise; *omettre*, to omit; *permettre*, to allow; *promettre*, to promise; *soumettre*, to submit.

13. MOUDRE, to grind, *moulant, moulu, je mouds, tu mouds, il moud, je moulus.*

14. NAÎTRE, to be born, *naissant, né, je nais, tu nais, il naît, je naquis.*

This verb is conjugated with *être* in its compound tenses: *je suis né*, I was born.

15. NUIRE, to injure, *nuisant, nui, je nuis, tu nuis, il nuit* (*je nuisis*).

According to the Academy, *nuire*, and *luire*, to shine, conjugated like it, have no past definite.

16. PLAIRE, to please, *plaisant, plu, je plais, tu plais, il plaît* (with circumflex accent), *je plus.*

The derivatives *complaire*, to gratify; *déplaire*, to displease; the reflexive verb *se plaire à*, to delight in; the verb *taire*, to conceal, hush up; and the reflexive *se taire*, to be silent, are all conjugated like *plaire*.

17. PRENDRE, to take, *prenant, pris, je prends, tu prends, il prend, nous prenons, ils prennent, je pris.*

This verb doubles the "*n*" before the endings *e, es, ent.* It has numerous derivatives which are conjugated like it, and amongst which are *apprendre*, to learn; *comprendre*, to understand; *entreprendre*, to undertake; *surprendre*, to surprise.

18. REPAÎTRE, to feed, to feast, is derived from *paître*, to graze; *repaissant, repu, je repais, tu repais, il repaît, je repus.*

This verb is also used reflexively: *se repaître*, and chiefly figuratively.

19. RÉSOUDRE, to resolve, solve, *résolvant, résolu, je résous, tu résous, il résout, je résolus.*

This verb also means to dissolve from one substance into another, and then has *résous*, *résoute*, for its past participle. *Absoudre*, to absolve, and *dissoudre*, to dissolve, are conjugated in the same way; but their respective past participles are *absous*, m., *absoute*, f., and *dissous*, m., *dissoute*, f., *Absolu* and *dissolu* are adjectives meaning absolute and dissolute.

20. RIRE, to laugh, *riant, ri, je ris, tu ris, il rit, je ris.*

Sourire, to smile, follows the same conjugation.

21. SUFFIRE, to suffice, *suffisant, suffi, je suffis, tu suffis, il suffit, je suffis.*

22. SUIVRE, to follow, *suivant, suivi, je suis, tu suis, il suit, je suivis.*

23. VAINCRE, to overcome, *vainquant, vaincu, je vaincs, tu vaincs, il vainc, je vainquis.*

Convaincre, to convince, is conjugated in the same way.

24. VIVRE, to live, *vivant, vécu, je vis, tu vis, il vit, je vécus.*

This verb has two derivatives, conjugated like it, *revivre*, to revive, and *survivre*, to survive.

EXERCISE XXXII.

1. When the ancients besieged (*assiéger*) a town they battered (beat) the walls with (*à coups de*) ram(s) (*le belier*).

2. One is never beaten without being struck (*frapper*); but one may (*peut*) be struck without being beaten.

3. The muleteer (*muletier*) who served us as (*de*) guide, beat his mules in a frightful (*épouvantable*) way (*la façon*).

4. We have concluded nothing, but that is not my fault.

5. He is an author whose works (*ouvrage*, m.) have been translated into all languages (*la langue*).

6. According to a distinguished writer (*écrivain*), if you always translate, you will never be translated; and yet (*cependant*) another writer, just (*tout*) as distinguished, has said that if you wish (*voulez*) to be translated (that one translate, *subj.*) some (*un*) day, you must yourself begin by translating.

7. I have seen him only once, but I should know him amongst (a) thousand.

8. That young girl sews, sings, reads; that is all she needs to be happy.

9. Who is it that used to say that, wherever (*partout où*) the lion's skin did not suffice, the fox's (*renard*) skin was to be sewn to it—that is to say, cunning (*la ruse*) to be joined to strength (*la force*)?

10. There are people who account the rest (*le reste*) of men as (*pour*) nothing, and think (believe) they are (to be) born only for themselves.

11. An honourable (*honnête*) man who says yes and no deserves (*mériter*) to be believed; his character (*le caractère*) swears for him.

12. Any (*tout*) author whom one is obliged to read twice to understand (*entendre*) him, writes badly.

13. What is written is written means (*veut dire*) that one can change nothing in (*à*) what is written.

14. The Good Shepherd (*pasteur*) has said: "I know my sheep and my sheep know Me."

15. It is admitted by all civilised (*civiliser*) peoples that the person of an ambassador is inviolable and sacred.

16. You depict (paint) the charms (*le charme*) of country (*champêtre*) life so well to us that you make us feel inclined to (*donner l'envie de*) go (and) live (*habiter*) in a (*au*) village.

17. The Gauls (*Gaulois*) used to transmit (the) news (*les nouvelles*) to each other by (*en*) lighting fires on the heights (*la hauteur*).

18. The days lengthen (grow) from the 21st of December to the 21st of June; they draw in (*décroître*) from the 21st of June to the 21st of December.

19. Men are like the flowers which appear and disappear with an incredible (*incroyable*) rapidity (*la rapidité*).

20. On the 11th of November, 1572, a new star appeared suddenly (*tout à coup*) in the sky, where it shone (*briller*) with (*de*) the most vivid (*vif*) brilliancy (*éclat*, m.); it disappeared in the month of May, 1574, after having lasted 16 months.

21. We read in Genesis (*la Genèse*) that the ancient patriarchs (*le patriarche*) lived a very long time, and that Abraham lived 175 years.

22. We write from left to right; the Jews write from right to left (*gauche*); the Arabs (*Arabe*) write similarly (*également*) from right to left.

23. The French overcame the Austrians (*Autrichiens*) at Jemmapes and at Marengo; they were overcome by the English at Waterloo.

24. The ancients used to grind corn with little millstones (*la meule*) worked (*mues*) by hand (*à bras d'hommes*).

25. Unjust actions always injure (to) their authors.

26. Cleopatra (*Cléopâtre*) took a large pearl (*la perle*) which she threw into a cup (*la tasse*), and, when she had seen it dissolved, she swallowed (*avaler*) it.

27. You laugh, and with reason, at (of) the folly (*les sottises*) of men, at which I should do (*ferais*) well to laugh also, and at which I would laugh if my digestion were better (if I digested, *digérer*) and if I slept better.

28. What (a) passion is (*que*) envy! It follows the man of merit even to (*jusqu'à*) the brink (*le bord*) of his grave (*la tombe*).

In all verbs the endings of the Imperfect Indicative, of the Past Definite, of the Future, of the Present Conditional, and of the Imperfect Subjunctive, are regular, whatever peculiarities there may be in the stem. Consequently, only the first person singular of those tenses will be indicated. Except in special cases, the Imperative will not be given, as its first and second persons are identical with the corresponding persons of the Present Indicative, and its third persons borrowed from the Present Subjunctive.

First Conjugation

1. **Aller,** to go, *allant, allé.*

Ind Pres.—je vais, tu vas, il va, nous allons, vous allez, ils vont.

Imperf.—j'allais. *Future.—j'irai.*

Past Def.—j'allai. *Cond. Pres.—j'irais.*

Imperat.—va, qu'il aille, allons, allez, qu'ils aillent.

Subj. Pres.—que j'aille, que tu ailles, qu'il aille, que nous allions, que vous alliez, qu'ils aillent.

Imperf.—que j'allasse.

The imperative *va* takes *s* when followed by *y*: *vas-y*, go there.

The compound tenses of *aller* are conjugated with the auxiliary *être*.

Idiomatic Uses of Aller. (*a*) *Aller* is used, in connection with another verb in the Infinitive, to express a proximate future, and then means "to be going to," "to be about to," "to be on the point of": *Je vais vous le donner*, I am going to give it to you; *J'allais vous écrire*, I was going to write to you.

(*b*) *Aller* also means "to suit," "to fit." It is frequently used instead of *se porter*, with reference to the state of health: *Son habit ne lui va pas*, His coat does not fit him; *Comment allez-vous? Comment vous portez-vous?* How do you do?

(*c*) *Aller* is used in the following expressions: *aller se promener*, to go for a walk; *aller à pied*; to walk (go on foot); *aller en voiture*, to drive, *aller à cheval*, to ride; *aller en bateau*, to go for a

sail; *y aller de* (impersonal), to be at stake; *il y va de la vie*, life is at stake.

(*d*) The Imperative of *aller* is used to form interjections: *Va! Allez!* Believe me; I can tell you; Surely. *Allons!* Come! Come now! *Allons donc!* Get away! Nonsense!

2. **S'en aller,** to go away, *s'en allant, s'en étant allé.*

Ind. Pres.—je m'en vais, tu t'en vas, il s'en va, nous nous en allons, vous vous en allez, il s'en vont.

Past Indef.—je m'en suis allé, tu t'en es allé, il s'en est allé, elle s'en est allée, nous nous en sommes allés, vous vous en êtes allés, ils s'en sont allés, elles s'en sont allées.

All the other tenses are conjugated in this way, by putting *m'en, t'en, s'en, nous en, vous en, s'en* between the subject and the verb.

Imperat. (positive).—*va-t'en, qu'il s'en aille, allons-nous-en, allez-vous-en, qu'ils s'en aillent.*

Imperat. (negative). *ne t'en va pas, qu'il ne s'en aille pas, ne nous en allons pas, ne vous en allez pas, qu'ils ne s'en aillent pas.*

The following examples will show the order of the words in interrogative and negative forms:

T'en vas-tu? Are you going away? *S'en est-il allé?* Has he gone away? *Je ne m'en vais pas,* I am not going away; *Ils ne s'en seraient pas allés,* They would not have gone away; *Ne vous en irez-vous pas?* Will you not go away? *Ne s'en est-elle pas allée?* Has she not gone away?

3. **Envoyer,** to send, *envoyant, envoyé, j'envoie, j'envoyai.*

The only irregular tenses of this verb are the Future and the Conditional.

Future.—j'enverrai. Conditional.—j'enverrais.

Key to Exercise XXX.

1. La terre est échauffée par le soleil.
2. L'égoïste n'est aimé de personne.
3. Les chiffres ont été inventés par les Arabes.
4. La femme fut trompée par le serpent.
5. Les orages sont prévus et annoncés par les hirondelles.
6. L'Amérique fut découverte par Christophe Colomb en mil quatre cent quatre-vingt-douze.
7. L'imprimerie fut inventée par Gutenberg dans le quinzième siècle.
8. Le cap de Bonne-Espérance fut doublé pour la première fois par les Portugais.
9. Quand êtes-vous revenu de Paris?
10. Quel jour vos amis sont-ils partis pour Londres?
11. Depuis que la comète est apparue une foule de gens passent la nuit à la regarder.
12. Quand nous sommes arrivés à la gare le train était déjà parti.
13. Il semble que le soleil tourne autour de la terre, quand, au contraire, il est certain que c'est celle-ci qui tourne autour du soleil.
14. S'il gèle le matin, il fait souvent beau toute la journée.
15. Il faut qu'une porte soit ouverte ou fermée, dit un proverbe français.
16. Je vous ai tout dit. Que vous faut-il de plus?
17. C'est justement ce qu'il me faut; merci.
18. Ses amis sont des gens très comme il faut.
19. Il s'en est fallu de bien peu qu'il ne fût tué.
20. Pour bien parler, il faut dire ce qu'il faut, tout ce qu'il faut, rien que ce qu'il faut, et le dire comme il faut.

Key to Exercise XXXI.

1. Notre brigade assaillira l'ennemi dans ses retranchements demain matin.
2. Quelques coups de feu partent; à ce bruit Napoléon tressaille; la campagne de Russie est ouverte.
3. Tout le monde sait que c'est Christophe Colomb qui a découvert l'Amérique.
4. Il n'ouvre jamais la bouche sans dire quelque sottise.
5. Le bruit qui se faisait dans l'assemblée couvrait la voix de l'orateur.
6. Il est certain que la mer a autrefois couvert une grande partie de la terre habitée.
7. L'eau bouillirait plus vite si vous allumiez un bon feu.
8. François premier dormit sur un affût la nuit de la bataille de Marignan.
9. Nous nous endormons tous les soirs pendant qu'il nous lit le journal.
10. Lorsque nous étions jeunes nous dormions douze heures sans nous réveiller.
11. Isaac ayant demandé à son père où était la victime qui devait être immolée, Abraham répondit: "Dieu y pourvoira."
12. Charles le Téméraire périt devant Nancy, trahi par un mercénaire napolitain, et tué en fuyant après la bataille, par un gentilhomme lorrain.
13. Fuyons ensemble au fond des forêts; il vaut mieux se fier aux tigres qu'aux hommes.
14. Il y a des gens qui mentent simplement pour mentir.
15. La satire ment sur les gens de lettres pendant leur vie, et l'éloge ment après leur mort.
16. On lui a offert une place à Paris, mais il ne désire pas quitter Londres.
17. Il est utile aux superbes de tomber, parce que leur chute leur ouvre les yeux.
18. On est ordinairement moins fâché quand on part que quand on voit partir.
19. Nous aurions dû partir pour la campagne hier, mais nous ne partirons que demain.
20. Quand tu mens, la conscience ne te reproche-t-elle pas quelque chose, et ne te repens-tu pas aussitôt?
21. Le juge qui est fidèle à son devoir ne sent ni regrets ni courroux.
22. Il y a des gens qui semblent croire que le bonheur de les servir est une assez haute récompense pour ceux qui les servent.
23. Sortez quand vous voudrez, mais je vous avertis que je ne sortirai qu'après que vous serez sortis.
24. Est-ce la peine de vivre quand on souffre? Oui, car on espère toujours qu'on ne souffrira pas demain.
25. Le malheur de ces gens qui savent tout, c'est qu'ils ne prévoient jamais rien.

Continued

SPANISH Continued from page 4388 By Amalia de Alberti & H. S. Duncan

IRREGULAR VERBS—continued

Third Class

This class embraces verbs of the third conjugation with a radical *e*, which is never expanded to *ie*, but changes into *i*:

1. Throughout the present indicative, excepting the first and second persons plural.
2. Throughout the present subjunctive.
3. Throughout the imperative, excepting the second person plural.
4. Throughout the rest of the conjugation, whenever the verbal termination contains the diphthong *ie* or *io*.

Servir, to serve. Gerund, *sirviendo*. *Ind. Pres.—sirvo, sirves, sirve, servimos, servis, sirven.*

Past Def.—serví, serviste, sirvió, servimos, servisteis, sirvieron.

Imperat.—sirve, sirva, sirvamos, servid, sirvan.

Subj. Pres.—sirva, sirvas, sirva, sirvamos, sirvais, sirvan.

Subj. Imp.—sirviera, sirvieras, sirviera, sirviéramos, sirvierais, sirvieran, or *sirviese, sirvieses*, etc.

Subj. Fut.—sirviere, sirvieres, sirviere, sirviéremos, sirviéreis, sirvieren.

The imperfect and future of the indicative and the conditional are regular.

Euphonic Changes. Verbs of this class ending in *eir* change *e* into *i* as usual, but drop the *i* of the diphthong *ie* in the verbal terminations in order to avoid the double *i*.

Reir, to laugh. Gerund, *riendo*. *Subj. Imp.—riera, rieras, riera, riéramos, rierais, rieran.*

These verbs also follow the same euphonic changes as the regular verbs—*viz.*: Those ending in *gir* change *g* into *j* before *a* and *o*.

Regir, to rule. *Ind. Pres.—rijo, riges, rige, regimos, regis, rigen.*

Subj. Pres.—rija, rijas, rija, rijamos, rijais, rijan.

Those in *guir* drop the *u* before *a* and *o*.

Seguir, to follow. *Ind. Pres.—sigo, sigues, sigue, seguimos, seguis, siguen.*

Subj. Pres.—siga, sigas, siga, sigamos, sigais, sigan.

Verbs ending in *ñir* drop the *i* of the diphthongs *ie* and *io* in the verbal termination.

Ceñir, to gird. Gerund, *ciñendo*.

This change is optional with verbs whose ending is *ch*; thus the gerund of *henchir*, to fill, may be either *hinchiendo* or *hinchendo*.

List of verbs of the third class, changing the radical *e* into *i*:

ceñir, to gird
colegir, to deduce
competir, to compete
concebir, to conceive
conseguir, to obtain
constreñir, to constrain
controvertir, to controvert
derretir, to melt
desceñir, to ungirdle
despedir, to take leave
desteñir, to discolour
elegir, to elect
embestir, to attack
expedir, to despatch
freir, to fry
gemir, to lament
henchir, to fill
heñir, to knead
impedir, to prevent
investir, to invest
invertir, to invert
medir, to measure
pedir, to ask
perseguir, to persecute
proseguir, to prosecute
receñir, to re-gird
reelegir, to re-elect
rendir, to render, surrender
reñir, to quarrel
repedir, to re-demand
repetir, to repeat
reteñir, to re-dye
revestir, to dress
seguir, to follow
servir, to serve
teñir, to dye
vestir, to clothe

Fourth Class

Irregular verbs of the fourth class end in *uir* and *güir*. The peculiarity of these verbs is the insertion of a *y* before the verbal termination:

1. Throughout the present indicative, excepting the first and second persons plural.
2. Throughout the present subjunctive.
3. Throughout the imperative, excepting the second person plural.
4. Throughout the rest of the conjugation, whenever the verbal termination should contain the diphthongs *ie* or *io* a *y* is substituted for the *i*.

Verbs ending in *güir* drop the diæresis before *y*.

Huir, to flee. Gerund, *huyendo*.

Ind. Pres.—huyo, huyes, huye, huimos, huis, huyen.

Past Def.—huí, huiste, huyó, huimos, huisteis, huyeron.

Imperat.—huye, huya, huyámos; huid, huyan.

Subj. Pres.—huya, huyas, huya, huyámos, huyais, huyan.

Subj. Imp.—huyera, huyeras, huyera, huyeramos, huyerais, huyeran, or *huyese*, etc.

Subj. Fut.—huyere, huyeres, huyere, huyeremos, huyereis, huyeren.

Argüir, to argue. Gerund, *arguyendo*.

Ind. Pres.—arguyo, arguyes, arguye, argüimos, argüis, arguyen.

The imperfect, future, and conditional of the indicative are regular.

All the following verbs are conjugated according to the above rule.

atribuir, to attribute
concluir, to conclude
constituir, to constitute
construir, to construct
contribuir, to contribute
destituir, to make destitute
destruir, to destroy
diluir, to dilute
disminuir, to diminish
distribuir, to distribute
estatuir, to enact
excluir, to exclude
fluir, to flow
imbuir, to imbue
incluir, to include
instituir, to institute
obstruir, to obstruct
prostituir, to prostitute
recluir, to seclude
reconstruir, to reconstruct
redargüir, to retort
refluir, to ebb
restituir, to restore
sustituir, to substitute

Vocabulary—Vocabulario

A witch	Una bruja	An oak	Un roble
Witchcraft	Brujeria (f.)	A lemon-tree	Un limonero
A sorcerer	Un brujo	An orange-tree	Un naranjo
A compass	Una brujula	A palm-tree	Una palmera
The mist	La bruma	A fig-tree	Una higuera
A brute	Un bruto	An ash-tree	Un fresno
To nod	Cabezear	A strawberry-plant — a strawberry-bed	Un fresal
The corpse	El cadáver	A raspberry-bush	Un frambueso
The locksmith	El cerrajero	A pomegranate-tree	Un granado
The bolt	El cerrojo	The reeds, rushes	Los juncos
The brewer	El cervecero	A laurel-tree	Un laurel
The beer	La cerveza	A mulberry-tree	Un moral
The basket	El canasto	A walnut-tree	Un nogal
A gift	Una dádiva	An olive-tree	Un olivo
A dagger	Una daga	An elm	Un olmo
Delight	Deleite (m.)	A poplar	Un álamo blanco
To date	Fechar	A pine-tree	Un pino
Weak	Débil	A pear-tree	Un peral
The tree	El árbol	An apple-tree	Un manzáno
An apricot-tree	Un albericoque	A plum-tree	Un ciruelo
An acacia	Un acácia	A willow	Un sauce
An almond-tree	Un almendro	A weeping willow	Un sauce lloron
A birch-tree	Un abedul	A lime-tree	Un tilo
The heather	El brezo		
Box (shrub)	Boj		
A cedar	Un cedro		
A cherry-tree	Un cerezo		
A chestnut-tree	Un castaño		
An evergreen oak	Una encina		

Exercise XVI. (1)

Translate the following into Spanish :

1. Honours are gained in serving one's country.

2. To follow bad example is evil; let us always follow good [example].

3. In girding on his sword he cried " Long live the King!"

4. We do not compete with that firm ; its prices are ridiculously low.

5. Do not buy this cloth : the colour comes out and stains the hands.

6. We cheerfully take leave of a disagreeable and tedious guest.

7. It is difficult to choose a travelling companion, but once chosen, one must be [on good terms] (*avenirse*) with him until the end of the journey.

8. One must reflect before investing one's patrimony, as when invested one runs the risk of being unable to withdraw it.

9. Let us measure the cloth before cutting out the cloak, and cut it according to the measure.

10. They pursued the enemy until they could proceed no further.

11. To quarrel with one's friends is the action of fools.

12. Let us contribute good works for the good of our neighbours, but let the contribution be judicious.

Exercise XVI. (2)

Translate the following into English :

1. Es tan vieja y fea que parece una bruja.

2. ¡ Lastimó à ese niño, es un bruto !

3. Ese hombre es un cervecero, ha ganado su fortuna vendiendo cerveza.

4. Me enseñó una daga muy antigua, es de un trabajo hermoso.

5. El fresal de mi jardin tiene de extension media legua.

6. En el huerto hay árboles frutales muy hermosos.

7. Los higos, las peras, y las manzánas son muy deliciosos.

8. El brezo crece en los montes.

9. Los limones y naranjas que crecen en nuestros limoneros y naranjos tienen fama por lo bueno que son. Tambien nuestros fresales crian fresas de gran tamaño.

10. La flor del granado es tan bonita como su fruta.

11. Es la moda de hacer muebles de junco, son bonitos pero poco duraderos.

12. El baj de la Alcazar de Sevilla es celebrado por su antiguedad y hermosura.

13. Con almendras y avellana se hacen en España un dulce que llaman turron que es muy bueno.

14. Los olivares son tristes y melancolicos, el verde de su follaje es cási negro.

Key to Exercise XV. (1)

1. Hemos cerrado todas las puertas, y ahora cierren Vds las ventanas.

2. No vale la pena rogar que lo perdonen ; ruegen Vds si quieren.

3. El olor de esas flores es un verdadero perfume.

4. Es dificil adquirir fama, y aún mas dificil conservarla despues de adquirida.

5. Es bueno alentar á la juventud ; yo la aliento siempre.

6. Es dificil aprobar cuando un amigo nos critica con verdad ; la aprobacion de los que nos rodean es necesaria para nuestra felicidad.

7. ¡ Hay que atender á nuestros negocios !

8. Tengamos cuidado al atravesar la plaza ; yó la atravieso siempre mirando á la derecha, y á la izquierda.

9. Dice el refran que no hay peor ciego que aquél que no quiere ver. El ser ciego acerca de nuestros defectos es natural.

10. Nuestra amistad fué cimentada hace años cuando sufrimos juntos. Las tribulaciones son buenas para cimentar buenas relaciones.

11. Este cuarto necesita que se caliente, y hay que calentar tambien el almuerzo.

Key to Exercise XV. (2)

1. The political exile to which he was condemned made his fortune when his party returned to power.

2. To awaken the anger of a passionate person is dangerous ; once awakened it is difficult to appease.

3. It is more difficult to man to govern his passions than to govern a nation.

4. I absolutely deny having said such a thing, and when they confront me with him, he will not be able to deny it.

5. It is said that it is better to patch one's cloak in time than to let the patch be bigger than the cloak.

6. He who sows thorns cannot expect flowers to spring up ; it is better to sow good seed than to sow thistles.

7. The fool dreams what he will, and the wise man what he can. Dreaming cannot be commanded.

Prose Extract XIII.

From a short story by Juan Ochoa, entitled :

" Liberty."	" Libertad."
Shade, shade of green leaves, was what both sought for in their hours of love.	Sombra, sombra de hojas verdes, era lo que buscaban ambos en las horas de amor.
How they sang together that spring! What tender things they said to each other on a tree-top swayed by the breeze !	¡ Cuanto cantáron juntos aquella primaverá. ¡ Cuantas ternezas se dijeron los dos en la copa de un árbol agitado por la brisá !
If looking up at the sky she burst into ecstatic song he would listen attentively with his tiny quivering head on one side, and when the last notes died away upon the beak of his mate he would shake his feathers, draw himself up prettily, and in his turn intone the lay of ardent love. The most magnificent and long-winded of linnets ! He was large and beautifully sleek of plumage. He had suffered grave and perilous adventures in his life. One morning he fell into a snare ; he saw four children wild with glee running towards him ; then he made a supreme effort and escaped ; leaving feathers behind, he bought the liberty of his wings with blood, but he succeeded in flying to the thicket, to the dark nooks of foliage, to the leafy home of his dreams. He flew far that day, eagerly drinking in the joy of liberty, and with a blow of his beak sle spide whe he surprised, lying in ambush for a fly.	Si ella mirando al cielo se arrobaba en su canción oiala él atento, ladeando un poco la cabecita temblorosa ; y cuando morían las ultimas notas en el pico de su compañera, sacudiase las plumas, se erguia con gentileza para entonar tambien la trova del amor ardiente ¡ Gilguero de más inspiración á más fachenda ! Era grande y tenía el plumaje limpio y hermoso. Habiá pasado en la vida sus aventuras serias y graves. Una mañana cayó preso en liga ; vió correr hacia él cuatro chiquillos locos de gozo ; hizo entonces un esfuerzo supremo y escapó, dejó allí plumas, compró con sangres la libertad de sus alas, pero logró huir á la espesura, á los rincones sombrios del follaje, al hogar de hojas de sus sueños. Aquel dia voló mucho, bebió con ansia la dicha de ser libre, y á una araña que sorprendió acechando matóla de un picotazo.
What labour love laid upon him and his mate ! Luckily she turned out the most industrious and wisest bird ever seen. She was up to everything. Thread, shreds, fluff, horsehair—she carried everything home in her beak to make the nest, and while her lover twisted and wove these	¡A cuantos afanes les llevó el amor, á él y á su compañera ! Gracias que ésta salió la pájara mas hacendosa y sabihonda que se habia visto. Estaba en todo. Hilos, brignos, tamo, cerdas, todo se lo colgaba del pico, y lo tráia á casa para el nido ; y mientras su amante emarañaba y

materials, she watched him lovingly, twittering softly, and suggesting her own plans also.

Thus they raised a temple to their love, and therein were happily united, hidden in mysterious foliage, having the blue of heaven, the rays of the sun, the caresses of the breeze, and the music of leaves for their wedding present.

They had a family, four rapacious imps who were transformed into mouths as soon as they smelt food; they had to be fed—expeditions must be made in search of food; they spent the whole day at it. The warmth of their feathers, the bread out of their mouths—nothing sufficed the gluttons. What drudgery!

One day when feathers had begun to grow on the

tejía aquellos materiales, ella le contemplaba enamorada, charloteando en voz baja y dando tambien sus planes.

Asi elevárou á su amor un templo, y en el se unieron felices, escondidos en la fronda misteriosa teniendo como regalo de bodas aquel cielo, rayos de sol, caricias de la brisa, música de hojas.

Tuvieron hijos; cuatro diablejos tragones, que todos se volvian boca en cuanto olian comida; había que cebarlos había que salir y buscar alimentos. En esto se pasaban el día. El calor de sus plumas, el pan de sus bocas—todo era poco para aquellos golosos. ¡Que fatigas!

Cuando los pequeñuelos ...menzáron á echar

little ones, and the tree was enlivened by their twitter, their parents went out in search of food. They returned at nightfall—they found no nest nor birds in the tree, there were none to feed. Then came mournful love, the wailing song, the measureless lament, which lost itself in the solitude of the grove. When night drew in they kept the vigil of their sorrow together above the ruins of the nest; they never closed their eyes, and they had no song to greet the light of dawn that day.

Juan Ochoa (1864–1899), a young author and journalist whose early death was a great loss to Spanish literature. He is renowned for the delicate beauty of his short stories.

pluma y alegrában el árbol con su charla, salieron un día los padres en busca de alimento. Volvieron al obscurecer. No halláron en el árbol nido ni pájaros, no tuvieron á quien cebar. Entonces comenzó el amor triste, el cantar llorando, la queja inmensa que se perdió en la soledad de la árboleda. Cuando cerró la noche, veláron juntos su dolor, sobre las ruinas del nido; no pegáron los ojos, y á la luz del alba de aquel dia no la saludáron cantando.

Juan Ochoa (1864–1899), un joven autor y periodista cuya temprana muerte fué una gran pérdida para la literatura española. Es afamado por la delicada hermosura de sus cuentos.

Continued

ESPERANTO

By Harald Clegg, F.B.E.A.

Esperanto is an artificial language perfected in 1887 by Dr. Louis Zamenhof, an oculist and linguist of Warsaw, and is so called from his pen name, "Dr. Esperanto" (the hoping one). It is intended to serve the purpose of an auxiliary language for international use, and possesses the advantages of extreme simplicity, logical construction, flexibility, and adaptability to present and future requirements, as well as ease of oral comprehension.

The language is now taught at many continental universities, lycées and military colleges, and is rapidly gaining favour at grammar schools and colleges in this country. The London County Council has made it a subject for instruction in its schools.

The lessons appearing in this course have been carefully graduated, it being assumed, however, that the student knows already the meanings of ordinary grammatical terms. He should aim first at reading, then at writing, and finally at speaking the language with ease.

THE ALPHABET

The Esperanto alphabet has 28 letters—*viz.*:

A (*a*)	B (*bo*)	C (*co*)	Ĉ (*ĉo*)
D (*do*)	E (*e*)	F (*fo*)	G (*go*)
Ĝ (*ĝo*)	H (*ho*)	Ĥ (*ĥo*)	I (*i*)
J (*jo*)	Ĵ (*ĵo*)	K (*ko*)	L (*lo*)
M (*mo*)	N (*no*)	O (*o*)	P (*po*)
R (*ro*)	S (*so*)	Ŝ (*ŝo*)	T (*to*)
U (*u*)	Ŭ (*ŭo*)	V (*vo*)	Z (*zo*)

The consonants are pronounced exactly as in English, with the following exceptions:

c as *ts* in its
ch hurch
g ,, gun or mug
g ,, gent or *dg* in edge
h ,, hot (always aspirated)
h ,, *ch* ,, loch (or German *ch*)

This is the sound of the ordinary *h* gutturally pronounced, and with considerable aspiration. It is represented phonetically by *kh*.

j as *y* in you, yet
ĵ ,, *zh*, or like *s* in pleasure
s ,, *s* in sit or bus
ŝ ,, *sh* in show, shift
ŭ. This letter, which is a consonant and equivalent to the English *w*, can never stand alone. It is always preceded either by *e* or *a*, and pronounced approximately thus:

aŭ as *ow* in cow; eŭ as *ay-oo* in gray-ooze,

the sounds being uttered close together, with one emission of the voice, so as to produce a single syllable. It must be understood that this example (gray-ooze) is not perfect—the true sound of *eŭ* not being found in any English word.

The five vowels are pronounced as follows, all being pure sounds and of medium length:

a as *ah*.
e as *eh*.
i as *ee* in *teem*.
o as oh (very round and entirely avoiding any approach towards *ow*.)
u as *oo* in *boot*.

Every vowel, no matter where placed in a word, is always clearly pronounced.

Besides the two combinations above there are four others, *aj*, *ej*, *oj*, and *uj*. Remember that the *j* here still retains the sound of the English *y* as before stated, so that these combined letters become: *ahy* (*al y*), *ehy*, *ohy*, and *ooy*, the sounds being found in: *pie*, *play*, *boy*, and *quill*. Each of these four combinations represents, of course, but one syllable.

Every word is *pronounced as written*. There are *no silent letters*. The *tonic accent* in every word which is not a monosyllable falls on the *penultimate* (last syllable but one). Give every letter its full sound and pronounce *nacio nah-tsee'-oh*, *alia ah-lee'-ah*; not *nah'ts-yoh* and *ahl-yah*. Slightly roll the letter *r* so that no ambiguity will arise when such words as *karto* and *kato* are pronounced.

Imitated Pronunciation. Read aloud the following words, carefully observing the pronunciation printed by each:

(The stressed syllables are indicated by accents.)

buŝo (*boo'-shoh*), multaj (*mool'-tahy*), tridek (*tree'-dehk*), Novembro (*Noh-vehm'-broh*), naskita (*nahs-kee'-tah*), infanojn (*een-fah'-nohjn*), amuze (*ah-moo'-zeh*), hodiaŭ (*hoh-dee'-ow*), klerulo (*kleh-roo'-loh*), neuzi (*neh-oo'-zee*), Eŭropo (*Ehoo-roh'-poh*), monaĥo (*moh-nah'-kho*), *scienca (*stsee-ehn'-tsah*) pezilo (*peh-zee'-loh*), ĉenigi (*cheh-nee-gee*), laciĝa (*lah-tsee-*

dgah), foriru (*foh-ree'-roo*), celante (*tseh-lahn'-teh*), nenion (*neh-nee'-ohn*), ĥinujo (*khee-noo'-yoh*), ŝipanaro (*shee-pah-nah'-roh*), plenaĝulo (*pleh-nah-dgoo'-loh*), ĵurintaj (*zhoo-reen'-tahy*), ie (*ee'-eh*), maja (*mah'-yah*), revolucio (*reh-voh-loo-tsee'-oh*), tiuj (*tee'-ooy*), iliaj (*ee-lee'-ahy*).

* The exact sound of *sc* is found in the last three letters of "mists" (mi*sts*).

THE ARTICLE

There is but one article in Esperanto—*la* (the), which remains the same for all genders, cases, and numbers. The indefinite articles, *a*, *an*, are not translated. The use of the definite article in Esperanto is very much the same as in English. It is used when the noun which follows must be distinguished from others of the same species. Ex.: *I have the* (*la*) *money* (the money which has been previously mentioned or referred to), which is different in meaning from *I have money*. *I sold the* (*la*) *horse* (a horse which must be distinguished from others). Nouns of abstract quality take the article *la*, as *La fiereco* (pride); so do all the arts and sciences, as: *La zoologio* (zoology), *la kantarto* (singing). The same remark applies to nouns indicating a whole species, as: *La homaro* (humanity), *la bestaro* (the animal kingdom). Generally speaking, the sense of a phrase determines the necessity for employing the definite article, but in all cases of doubt it should be omitted.

THE NOUN

As will be seen by reference to the vocabularies, Esperanto words are built up from roots which are given a definite meaning, and to this particular attention must be paid. Some of the roots are by nature essentially substantival, others adjectival or verbal, and in adding *o* to form the substantive, *a* to form the adjective, etc., care must be taken to see that the word so constructed bears a translatable meaning. The force of this remark will appear later when the *terminations* have been fully dealt with.

Nouns are formed by adding *o* to the root, when *singular* and in the *nominative* case.

Thus: *Infan-o, dom-o, patr-o, pord-o.*

To form the *plural*, add *j* to the *o*, thus making the words *infanoj, domoj, patroj, pordoj.*

When, however, the noun (singular or plural) is in the *accusative case*—*i.e.*, when it is affected by some transitive verb of which it is the direct object—a final N is added. Ex.: I have a fine house (*domon*); He sold me two doors (*pordojn*).

In the latter phrase, *me* is the indirect object of the verb, and in Esperanto is governed by a preposition. Here it may be advisable to explain why Esperanto uses an accusative case, and thus adopts an apparent complication which other languages have abandoned as unnecessary. In English, however, we see it in the pronouns:

I (nominative), me (objective), they (nominative), them (objective), and so on, but nouns in the nominative and objective cases are alike. In a phrase such as "Father likes mother more than you" we cannot tell whether father's liking for mother excels yours, or whether father prefers mother to you. There is, moreover, another use for the Esperanto accusative which will be dealt with in a subsequent lesson. This one simple principle, while allowing freedom to the order of words in a phrase, permits a single conjugation of the verb and does away with the necessity for duplicating pronouns. As a consequence, Esperanto is more supple than any natural language, and far more precise in the meanings it has to convey. Confusion, such as the above English phrase exhibits, can never arise in Esperanto, thanks to the adoption of one general rule, which, after all, is easily grasped.

Nouns in Esperanto have no possessive case, this being rendered by *de* (of). Sometimes a possessive noun may be conveniently translated by an adjective.

Ex.: *Ŝafa felo* (sheep's skin).

THE VERB

The whole of the moods, tenses, and participles of Esperanto verbs are formed by the addition of twelve terminal particles to the roots. Their conjugation is absolutely regular.

The *infinitive mood* of the verb is formed without exception by adding *i* to the root. Ex.: *Kuri*, to run; *fermi*, to shut. The sole auxiliary verb is *esti* (to be) which entirely displaces the use of equivalents for the English auxiliaries *to have* and *to do*.

The *present tense* is formed by the addition of *as* to the root word, and this form is used for 1st, 2nd, and 3rd persons, both singular and plural. Ex.: Infants sing, are singing, do sing, *infanoj kantas*; the father sells, is selling, does sell, *la patro vendas*.

VOCABULARY

The words in each vocabulary should be thoroughly learned by uttering them aloud before proceeding with the exercise. Those which are indeclinable are distinguished by an asterisk.

aĉet', buy
admir', admire
agl', eagle
akcept', accept
bak', bake
baston', stick (cane)
best', animal
bird', bird
bov', ox
brul', burn (*v.n.*)
ĉapel', hat
ĉas', hunt (pursue)
dank', thank
dent', tooth
edz', married person (husband)
ferm', shut
fenestr', window
gazet', gazette
hav', have (possess)
**kaj*, and
kol', neck
kuz', cousin (male)
labor, work (*v.n.*)
man', hand
onkl', uncle
paper', paper
pip', pipe (tobacco)
pun', punish
ŝaf', sheep
seĝ', chair, seat
skrib', write
star', stand (*v.n.*)
tabl', table (furniture)
vost', tail
vid', see (*v.*)
vir', man

Exercise I.

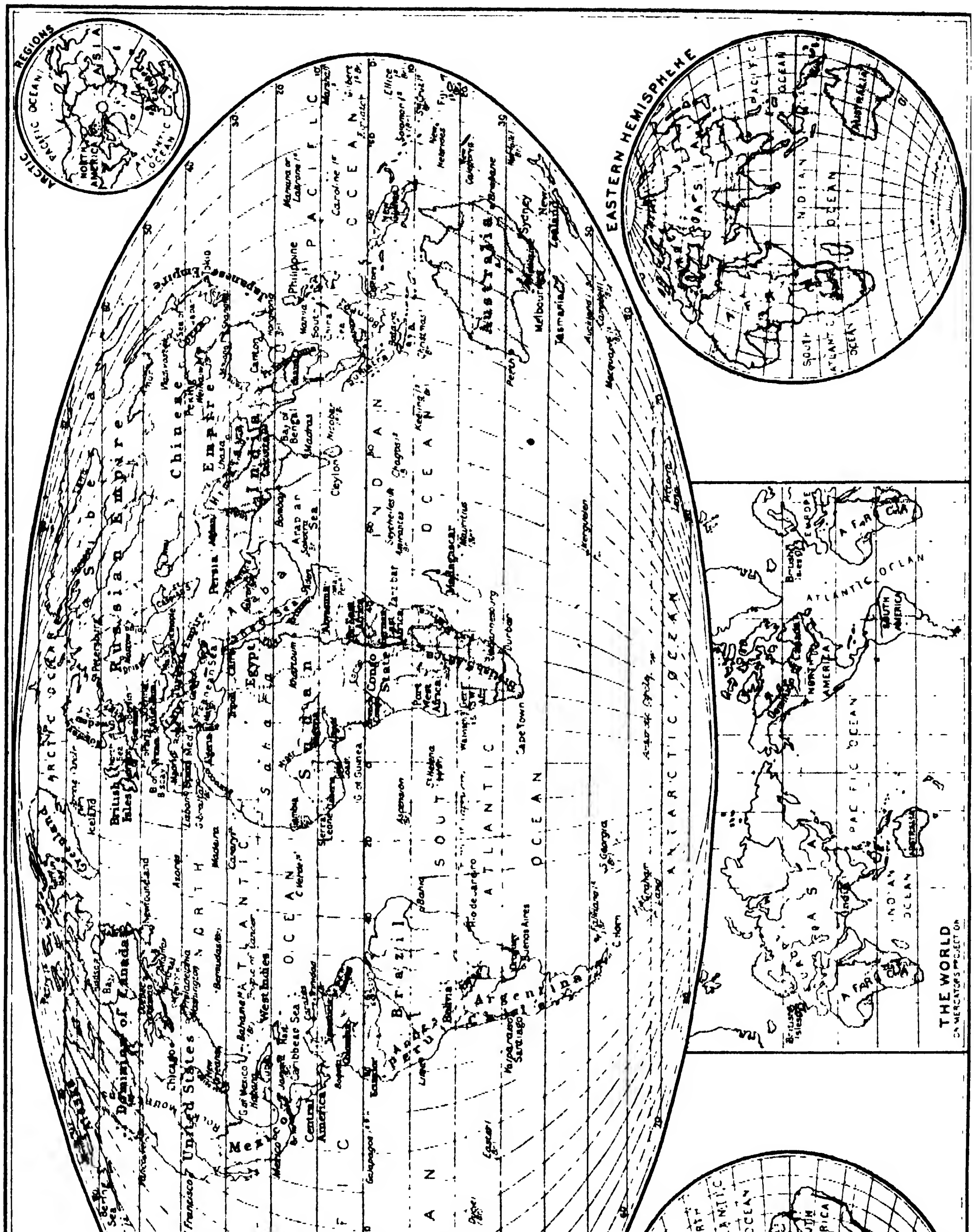
Translate into Esperanto and repeat the words aloud when written:

Uncle, sheep, the stick, the windows, to write, to thank, to punish, to shear, to see. The cousin works. The husband writes. The sheep stands. Uncle punishes. The sheep run. The husband buys some[a] gazettes. Father admires the eagle. The child clips the paper. The eagle is a bird.[b] Uncle has a chair, a table, and a stick. Sheep and oxen are animals[b]. The father shuts the windows. The husband has a hat and the sheep have tails. The eagle sees the children. The child thanks the father. The man bought a table and some[a] chairs. The man accepts the hat.

a Not translated.

b When the predicative complement is identical with the subject of the sentence, it is in the nominative case.

Continued


ARCTIC REGIONS
EASTERN HEMISPHERE
THE WORLD
WESTERN HEMISPHERE
ANTARCTIC REGIONS

ADAPTING EARTH TO OUR NEEDS

Man, the Trader. Utilising the Earth's Raw Materials. Transport by Land and Sea. Power and Manufacture. Canals. Rivers. Railways. Towns and Ports

Continued from page 4198

By Dr. A. J. HERBERTSON, M.A., and F. D. HERBERTSON, B.A.

THE chief barriers to communication by sea are the Isthmus of Suez, between the Mediterranean and the Red Sea, necessitating the long voyage round the Cape; and the isthmus of Central America between the Atlantic and the Pacific, entailing the rounding of Cape Horn. The first has been overcome by cutting the Suez Canal. The cutting either of the Panama or the Nicaragua Canal across the second is only a question of time. The stormy route round Denmark is avoided by the Kaiser Wilhelm Canal across the base of Jutland, and the Corinth Canal saves the long route round the Morea. A ship canal between the Forth and Clyde would give a short route from the Atlantic to the North Sea.

The natural regions of tundra, temperate forest, steppe, desert, and tropical forest have already been described. These are not arranged in parallel zones, but according to variations of configuration and climate. Each zone has its special products, the general nature of which has already been indicated.

Adapting the World to Man's Needs. Man differs from all other animals in his higher intelligence and his more complex wants. Only in the earliest stages of civilisation has he been contented to take the world as he found it, without attempting to adapt it to his needs. If we look at the lowest existing races, we see in them the germs of that ingenuity and inventiveness which has made the highest races what they are. In the course of ages man has done much to change the world he originally found. He has modified vegetation and animal life, diverted rivers, drained lakes, tunnelled mountains, and cut canals from sea to sea. In all this he has had one main end in view, the desire to obtain a fuller command of the world and its resources.

The first stage was when men lived exclusively on what they could find—dead animals, fish left by the receding tide, and the fruit, leaves, and roots of plants. It is difficult to find examples of peoples at this stage so immediately do men begin to invent devices for improving their food supply. Mere collecting of this kind is still the chief resource of the people of Tierra del Fuego, of the South African Bushmen, and of many Australian tribes.

Man, however, soon becomes a hunter, and makes weapons. Some of these—the Australian boomerang, which returns to the thrower, or the Eskimo harpoon, for example—are extremely ingenious. Civilised man has the same instinct, and invents weapons of diabolical precision and destructiveness with which to achieve his ends.

Hunters in the Old and New Worlds. Hunting is essentially a destructive occupation. It is continually reducing the food supply, and making existence more difficult. As small areas are soon cleared of game, hunting peoples require a very large range of country, and as they have to pursue their prey, they rarely have settled homes. The lowest hunting tribes build rude shelters where they may happen to want them. Similarly, the wealthy sportsman who goes far afield in search of sport carries elaborate tents and outfits. In both cases it is impossible always to return to the same spot at nightfall.

When Europeans discovered North America the prairies fed great herds of bison, which were hunted by Indian tribes. The Australian tribes hunted the kangaroo and other animals. The pygmy tribes of the tropical forest are skilled hunters. The Eskimo hunts the seal and walrus, making the sea his hunting ground. Among more advanced peoples hunting is only one among many occupations. The trapping of fur animals is important in the temperate forests of the Old and New World, but it is for exchange, and no longer for food. The Eskimo are true hunters, but the crews of whaling and sealing vessels are in a transition stage. In the long run both classes die out. Generally, it is because the game is exterminated, for this is the penalty which Nature exacts from those who destroy without renewing. Often the end is accelerated, as in the American prairies, or in Australia, by the advent of a more advanced race with superior weapons, who deliberately exterminate the game to put the land to more profitable uses. Deprived of their hunting grounds, the aboriginal people quickly perish.

Man as a Creative Agent. It is far otherwise when man begins to create. This he has done by domesticating and breeding animals, and by practising agriculture. The shepherd or the farmer is obviously a more useful type than the hunter, and one likelier to become rich. In the great grass lands of the world the pastoral peoples predominate. Agriculture of a more or less complex kind is practised wherever there is the least chance of success. Even the majority of hunting peoples have some rudimentary knowledge of agriculture, which has become the mainstay of the highest races. Both agriculture and the breeding of animals become more and more scientific as a race increases in civilisation, ensuring a larger and more certain return for the labour expended.

Man's control of Nature is thus continually increasing, though there are innumerable agencies ever liable to undo his work. Some of these are climatic; others are of plant or animal origin. Untimely frost, rain, hail, or drought

may ruin his crops and involve the loss of his livestock. Lower forms of plant life may cause blight, mildew, and other plant diseases. The animal foes range from microscopic organisms to highly organised animals. The former are the unseen causes of disease, malaria, yellow fever, etc. The ravages of the phylloxera insect have caused immense loss to nearly all vine-growing countries. The mosquito renders large districts uninhabitable by carrying the germ of malaria. The African tse-tse fly exterminates cattle over the areas it haunts. The locust, the scourge of South Africa and other dry lands, annihilates every trace of vegetation in the line of advance. The rabbit has become an equally serious plague in Australia, where it does great damage both to crops and pasture. Many other examples will doubtless suggest themselves.

Man's Utilisation of Raw Materials. A society which breeds animals or practises agriculture has a constant supply of raw materials. The shepherd peoples have immense quantities of wool and hair, out of which they make felt tents, wool carpets, leather bottles, saddlery, and so forth. The agricultural peoples have bursting barns and laden fruit trees in autumn. Fruit must either be used immediately or wasted. Thus begin such industries as the making of wine. It is needless to follow out the process in detail, or to mention the manifold ways in which the raw materials of the entire world are utilised in a complex society like our own.

Originally, all power was hand power, as it still is in many parts of the world. Labour may be so cheap that hand power is the most economical, as in China; or a region may be so remote that labour-saving devices have not penetrated to it, as in the hand grinding of cereals in many African villages, or, in exceptional cases, such as lacemaking, the hand may give a finer result. Animal power probably developed next. A common example of it is the use of animals in ploughing. Horse power remains our unit of measure, though we now employ mechanical power wherever possible.

Power — Water, Steam, and Electricity. Water power was the first mechanical power employed, and the command of it was of prime importance until the introduction of steam power in the eighteenth century. Steam power enormously increased output, and the impetus thus given to manufactures led the conveniently-situated coalfields of Europe and North America to specialise in manufactures to the almost complete exclusion of agriculture. Steam power is now being rapidly displaced by electric power, which is restoring the command of water power to its old importance. The fact that it can be cheap'y generated by water power, transmitted for long distances, and put to the most varied uses, gives it a superiority to every other form of power with which we are yet acquainted. Its increasing use is one of the great secrets of civilisation, and its increasing application in all parts of the world will almost inevitably lead in the long run to redistribution of population.

The geographical and human factors together produce great diversity of raw and manufactured products. Some system of exchange early begins, and increases in complexity as societies develop.

Exchange and Transport. For exchange two things are necessary—a surplus of some commodity and the means of putting it on the market. Without the latter the former is useless. Transport will therefore be briefly considered before commodities.

Transport is carried on either by land or water. Transport by land is carried on first by road, and much later by rail. In transport by road goods are carried by human porters or by beasts of draught or burden and recently by mechanical power. In transport by rail a locomotive is driven by mechanical power, or carriages are propelled by electricity. By water, oars, sails, steam or other mechanical powers are employed, and on inland waterways haulage—usually by horses.

Women are the oldest beasts of burden in the world, and still do most of the carrying among savage tribes. Slave labour is notoriously associated with the ivory trade, carrier and burden being sold together at the end of the journey. Slave labour is being eliminated by the progress of civilisation, but human carriage is by no means at an end. On a limited scale, it survives among ourselves. It may be the only form of transport possible under certain conditions, as, for example, in those parts of Africa ravaged by the tse-tse fly, whose bite is fatal to animals. In the tropical forests to make and keep roads open is almost impossible, and human carriage must frequently be resorted to.

Human Carriers. Human transport is slow and dear. A slave must be bought as well as fed, and as he may die on the march, a speculative risk is incurred. A free porter requires wages in addition to food, which an animal does not. Limitation is also set by human strength. A man can carry only a given load. If part of this consists of his own food, the expense becomes still more prohibitive. Always dear, human transport is only practicable in fertile regions, and then only on a very limited scale. Hence, such a region as our Colony of Nigeria develops very slowly. There is abundance of valuable produce in the interior, but it cannot be got down to the coast. The time would be prohibitive, and the cost at the present rate would work out at about £10 per ton per 100 miles.

Transport by human carriers therefore greatly hampers the rapid growth of trade, and can only be applied to goods which are not perishable, and where bulk is small in proportion to the value. Such a trade is that in brick tea across the high mountains separating China from Tibet. In no country, however, is human labour so cheap as in the rice lands of China and India, and nowhere is human carriage so common. An economy is effected when man is made into a draught animal, for he can pull larger loads than he can lift. In China wheelbarrows are largely used. Sails are sometimes attached to them, but rather to increase the load than to lessen the labour.

Animal Carriers. Animal transport is also a very ancient mode of transport, though still in daily use among ourselves. It is both quicker and cheaper than the preceding, especially if draught are substituted for pack animals. The reindeer in the tundra of the Old World, the horse in temperate Europe, the mule in southern Europe, the ox in South Africa, the camel in the hotter, drier regions, are among the draught and pack animals of the world. The yak crosses the high passes of Tibet, and the llama those of the Andes. There are, however, the same limitations as in the case of human labour. Expense is enormously increased if part of the animal's load consists of its own food. Hence the value of the camel where it can be used. This animal has fat-storing cells in its humps and water-storing cells in the coats of its stomach. Cases are recorded of camels remaining without water for two months. The average load is from 6 cwt. to 8 cwt. The cost of camel transport in Manchuria has recently been given at from 1½d. to 2d. per ton per mile, while transport by mule or pony cart comes out rather cheaper.

Before the introduction of railways, nearly all the transport of the world was done by animals. Great trade routes crossed the Old World, many of which are now followed by railways. At the present time animal transport is chiefly used to get goods to the nearest railway or waterway. It may cost the American farmer as much to haul his grain to the railway as will be paid for the rest of its transport to Europe. Hence, farming does not pay beyond a certain distance from a railway.

Transport by Rail. Transport by rail is quick, reliable, and particularly suitable for perishable commodities. Though dearer as a rule than water carriage, it is far cheaper than either of the preceding.

Three principal elements enter into the question of cost—(1) The initial cost of constructing the track; (2) the cost of the locomotive and other rolling stock; and (3) the working expenses. The examination of these in detail does not fall under the scope of geography. It may be pointed out, however, that the question of gradient and distance are of prime importance in determining working expenses. It requires more power to lift a weight up an incline than to draw it on the level. Hence, other things being equal, the route with the easiest gradient will be chosen. An example of this is seen in the case of the recently-finished Simplon Tunnel.

It was decided to pierce a long tunnel at a lower elevation rather than a much shorter tunnel at a higher elevation. The extra cost involved in hauling every ton to the higher level would in the end have more than counterbalanced the initial economy in the cost of the tunnel. Where a steep gradient is unavoidable, the rate charged is often prohibitively high. The cost of ascending Vesuvius by rail is £1 for a journey of a few miles. Here, no doubt, the element of monopoly comes in, but the working expenses on such a line are necessarily exceptionally high.

The shortening of the distance to be traversed is almost as important as the easing of gradient. A longer route means an increased consumption of fuel on every journey, as well as loss of time. Hence, to reduce distance is to reduce cost. Economy of time is rapidly becoming the only real economy, and from this point of view such costly engineering works as tunnels through the Alps and the Andes pay in the end. Tunnels are even carried below estuaries and narrow arms of the sea to avoid the time and expense of unloading and reloading.

Another element in reducing cost is the distance hauled, long hauls costing relatively less than short ones. The cost of loading and unloading is the same in both cases, so that this is another example of economy everywhere effected under modern conditions by economy of time.

Transport by Land and Water. The total mileage of the world's railways is over 500,000 miles, by far the greater part being in Europe and North America. A through line, though not on a uniform gauge, crosses Europe and Asia from the Atlantic to the Pacific. Several lines cross North America, and in South America a transcontinental line is in process of completion. A Cape to Cairo railway is projected.

Transport, like manufacture, is passing into the electric stage. Both trams and railways are now driven by electricity.

Transport is carried on by river, canal, lake, and sea. The boat or ship replaces the animal or the locomotive. It is the cheapest form of carriage—(1) Because, except in the case of canals, no roads have to be made and kept in repair; (2) because a smaller power will move a given tonnage through the water than would suffice on the most perfectly-graded railway; and (3) because it is less easy to create a monopoly, and competition tends to reduce rates. Very heavy and bulky goods can often be carried more cheaply by water than by land when both methods are available. In the case of ocean commerce, there is, of course, no alternative to water carriage, though there may be a choice between the use of wind power and steam or electric power.

The Commercial Value of Rivers. Rivers are natural roads between the sea and the interior of a country. Their upper courses are often too swift and steep for navigation, but in the lowlands they are generally navigable. Their commercial importance increases as a country develops. It would be impossible to overestimate the value of the Rhine to Germany, the Danube to Austria, the St. Lawrence to Canada, or the Yangtse to China.

Various causes lessen the value of a river as a means of transport. Its current may be too swift, as in the Hwang-ho. It may be liable to floods, as the Loire. It may be too shallow, as the Elbe, which is not navigable in its upper course in dry summers. Its bed may be broken by falls or rapids, as at the Iron Gates of the Danube, now made navigable by blasting away some obstructions, and making a canal to avoid others. All the African rivers suffer in this respect. Africa is a high plateau, falling by steep terraces to the sea. Over these the rivers

fall to the coastal plains, forming falls. They are navigable above and below these, but they are not natural routes from the sea to the interior.

Another drawback is the tendency of rivers to form bars at their mouths. This is well seen in the case of the Rhone. It has a large delta, and bars are formed at the mouth of all its distributaries. Aigues Mortes, once a flourishing port, is now inland, and the port of the Rhone valley, Marseilles, is east of the delta.

Thirdly, a river is of little use for transport if the approaches to it are not good. This is illustrated by the Danube. The Rumanian bank is low and marshy, while the Bulgarian bank is high and above flood level. Hence, Rumania makes much less use of the Danube for transport than does Bulgaria.

Again, it is a disadvantage if a river be icebound in winter, as transport must cease. When the St. Lawrence is frozen much trade is diverted from Canadian to American ports. Most of the rivers of Eastern Europe, including the Danube, are icebound in winter. Siberia is handicapped in the same way, and the Amur, the other great river of Asiatic Russia, is closed to navigation from November to April.

Transporting Timber. A very primitive mode of river transport may still be seen on the Rhine, and on most of the rivers of Europe which flow from forested regions. The timber is made up into great rafts, which are towed or floated down stream. This mode of transporting timber is practised all over the world—in Canada, where the Ottawa is the busiest timber river; in Brazil, where mahogany is floated down stream; on the rivers of Burma, which carry teak; on the Amur, where timber is floated down from the forests of Manchuria; and on the Yangtse, from the dense forests between China and Burma. On the last named river logs are floated down in January, and take about six months to travel 600 miles.

Few goods, however, would stand such rough handling, and the usual method of transport is by boats, which assume innumerable forms in different parts of the world. In the chief commercial countries river transport is carried on by steamers of suitable draught. The estuaries of many rivers admit ocean-going steamers far into the interior. The Seine is navigable for ocean liners to Rouen, and to coasting steamers even to Paris, the Rhine to Cöln, and to coasting steamers to Mannheim. Compare this with the Rhone, which is inaccessible to ocean-going vessels.

Lakes. Lakes are of all sizes, the largest assuming the dimensions of inland seas. When of any size they are generally utilised for transport, which may be chiefly passenger traffic, as on Loch Lomond, or may include freight. Whether freight can be profitably carried depends on various considerations, one of which is tran hipment. Where lakes do not communicate with the sea the traffic is necessarily local. In a country where roads are few the navigation on lakes may be of great importance. Consequently we find steamers plying on Lakes Nyasa and Tanganyika in the heart of Africa. Where lakes are connected with the sea by a navigable river, the advantage for transport is obviously greater. No better example can be found than the Great Lakes of the St. Lawrence.

The Commercial Use of Canals. Canals are artificial waterways. They include inland canals for river traffic and ship canals for ocean traffic.

Inland canals are made to improve existing rivers, to connect navigable rivers with each other, or to avoid obstructions. The rivers of England and the Continent have been extensively canalised, and connected with each other by canals. Sometimes the canalisation and deepening of a river bed calls a new port into existence. The deepening of the Clyde and the rise of Glasgow is a case in point. At the end of the eighteenth century there were only 15 inches of water at Glasgow at high tide. To-day it is a port for the largest liners afloat. Similarly Montreal has been artificially made into an ocean port.

Canals are frequently made to avoid obstructions to navigation. The navigation of the St. Lawrence above Montreal is obstructed by the Lachine Rapids, three miles long, now avoided by the Lachine Canal, from Montreal to Lachine. This is nine miles long, and rises 45 ft. by means of five locks. There are altogether 42 miles of canals between Montreal and Lake Ontario. Other canals avoid the obstruction between lake and lake. The Welland Canal, between Lakes Erie and Ontario, avoids the Niagara Falls.

Canals versus Railways. At the present time the canal question is exciting much interest. In this country the canals have suffered from railway competition. Very primitive methods of canal transport are used, chiefly barges towed by horse power, and so small that goods cannot be handled in bulk, a factor in reducing expenses. The rate is very slow, and can be profitably applied as a rule only to bulky goods not of a perishable kind, such as coal, or building stone. In view of the often repeated axiom that time saved is money saved, canal transport must be accelerated if it is to pay. A possible change of method is illustrated by a short canal just opened in Prussia.

The Teltov Canal, which is about 24 miles long, passes through the forests and lakes to the south and south-west of Berlin, and connects the upper Spree with the Havel near Potsdam. It shortens the distance for barges passing from east to west by the canals connecting the Elbe and Oder, and relieves the congestion of the river traffic through Berlin. The special feature of this canal, which is all but unique in Europe, is the mode of traction. Electric locomotives, supplied with power from overhead wires, run along the banks, and tow the boats in either direction. Each can tow 1,500 tons at the rate of three miles an hour. [See 4, page 2275.] The rates at present charged for towing are high, one penny per ton per kilometre ($\frac{5}{8}$th mile). The result of this new experiment in canal transport remains to be seen.

Canals have declined owing to the competition of railways. For this geographical causes are to some extent responsible. A region suited for the construction of a canal is also well adapted for the construction of a line of easy gradient, which is inexpensive both in construction and working. Before the development of railways many hundreds of miles of canals were made along the valleys of eastern Pennsylvania to carry coal down to the markets. None of them are now important, for the whole route being on the down grade, the railways can carry it very cheaply, as well as more quickly, and in greater bulk.

Ship canals are made either to shorten routes, as in the Suez Canal, or to bring inland towns into direct communication with the sea. The Manchester Ship Canal was constructed at a cost of £15,000,000 to make Manchester a port and to avoid transhipment at Liverpool.

Transport by Sea. Transport by sea is of unknown antiquity. At the dawn of history we find the Phœnicians on the Syrian coast possessed of a great navy, and trading with all parts of the known world. Their ships were propelled by rowers, and sails were used only as an auxiliary means of power. Up to the beginning of the nineteenth century the world's ocean commerce was carried on entirely by sailing vessels. The first steamer crossed the Atlantic in 1819, and ever since there has been a steady increase in the ratio of steam to sailing vessels.

Steam transport is initially costly. In addition to the cost of the vessel, which is much more than a sailing vessel, there is the fact that machinery wears out rapidly or becomes out of date, so that the life of a steamer is shorter than that of a sailing vessel. Further, there is the permanent charge for fuel. The fastest liners consume nearly 400 tons of coal a day. This expense has not to be met by sailing vessels. To counterbalance the heavier working expenses it must be remembered that a steamer can carry far more per annum, which makes for economy. As in the case of locomotives, improvements in the construction of engines have resulted in a great economy of fuel, thus lowering rates. In some cases these are only half what they were 25 years ago.

Where Steamers Beat Sailing Vessels. In addition to their greater carrying power, steamships possess another great advantage over sailing vessels. The latter are dependent on winds, and must often shape a longer course to get a favourable wind. The steamer is practically independent of wind, and can choose the shortest route. Nowhere is this better illustrated than in the case of ships on their way from the Indian Ocean to the Atlantic. The rates for towing in the Suez Canal are so high that most sailing vessels take the route round the Cape, though it is 3,000 miles longer. A steamer, of course, does not require towage. The acceleration in delivery makes steam carriage the most economical for all perishable commodities.

The introduction of steam transport has caused a certain oscillation in the situation of ports. Originally, when all vessels were sailing craft of limited size, the ports tended to be at the head of tidal navigation. As steam came into use and vessels increased in size they were no longer always able to reach the inland port, and ports nearer the mouth of the river rose in importance. The advantage of penetrating as far as possible into th interior was, however, of such great commercial importance that the more important rivers of Europe were deepened and dredged to make them accessible to ocean-going steamers for the longest possible distance. Thus commerce flowed back again to the port nearest to the interior, which rose at the expense of its former rival at the mouth of the river.

The Beginning of Towns. The earliest settlements of man were determined by ease of access to certain commodities, without which life is impossible. The two most fundamental are water and food. Next to these comes the presence of some material for making weapons. In our own country primitive man made his weapons of flint, and traces of early settlement are found all over the chalk counties of Britain. A second important consideration was ease of defence. This led to the forming of settlements on hills (Edinburgh), or on islands in a river (Paris), or on firm ground surrounded by marshes (Ely). So long as each settlement was small and relatively self-sufficient, these two considerations were probably all important. Some simple form of exchange early developed, and along with it there was an irresistible tendency for settlements to grow up at certain points of vantage. Broadly speaking, these were concerned with the control of routes. A good example is the growth of a village at a point where a river could be forded (Oxford), or bridged (Cambridge). The nucleus of what has become the greatest city in the world was the ford of the Thames at Westminster, and the bridge across the river a mile or so below it. Another obviously good site is the confluence of two rivers. Duisberg, Coblenz, and Mainz are all confluence towns on the Rhine. At Nizhni Novgorod, at the junction of the Volga and the Oka, an annual fair is held, at which the business of two continents is transacted. Where a river changes its direction an important town frequently grows up, owing to the convergence and divergence of routes in different directions. Such a town is Basel, where the Rhine turns north across the Upper Rhine Plain.

The command of land routes is equally important. London had not merely its ford and bridge, but it was at the end of the only practicable routes across the otherwise impassable marshes. Towns naturally arise at the mouths of valleys (Heidelberg), especially when these lead to important passes (Turin, Milan, Verona). Towns also grow up at the mouth of gaps or depressions across mountain ranges (Salisbury, Winchester). Basel is at the end of the important route by the Burgundian Gate, so that two distinct causes have promoted its growth.

The Beginning of Ports. Another series of towns is associated with the change from one form of transport to another. The most obvious

illustration is the ordinary seaport, where land and water routes meet. A large and important town almost inevitably grows up at the head of navigation for large vessels, where freight must be transhipped from or to smaller steamers, or to the rail. This explains the rapid growth of Mannheim. There will also, for a similar reason, be a considerable port at the head of tidal navigation, the limit for any smaller vessels. If the river be interrupted by rapids, transhipment may be necessary, and consequently a town will grow up (St. Paul in Minnesota, Detroit, Montreal). Even under more primitive conditions the same law holds good. Ta-chien-lu, the centre of the tea trade between China and Tibet, owes much of its importance to the fact that here the tea is transferred to yaks, the beasts of burden on the high passes of Central Asia.

The Position of Manufacturing Towns. The position of manufacturing towns is due to a different set of conditions. Anciently they tended to grow up where raw material and control of water power were both available, as in the woollen towns of the Tweed valley, Yorkshire, the Cotswold, the Ardennes and Saxony. The existence of some other favourable circumstances might be the determining cause. Thus many of the Flemish rivers have special bleaching properties, and towns engaged in the linen manufacture grew up along the Lys and other rivers. The most striking case is the rise of manufacturing towns on the coalfields of Britain, Europe, and the United States after the discovery of steam power. The cotton towns of Lancashire possess three advantages of position. Two of them are obvious—proximity to coal and to the cotton-shipping ports of the United States. The third is climatic. The humid atmosphere enables a fine thread to be spun, and gives a better result than the artificial dampening of the air in drier districts.

Where several of these advantages are present the prosperity of a town is more likely to be permanent than where there is only a single one. Space forbids an analysis of the advantages of position possessed by the chief cities of the world, but in almost every case it would show that these are very numerous.

The Advantages of Seaports. Unless the hinderland be poor, the balance of advantage lies with seaports. A large population finds employment in handling the merchandise brought in and out. Every grade of labour is represented, from the merely manual tasks of loading and unloading, through the various agencies of distribution to the highest forms of administrative ability, which shape the destiny of whole communities by regulating the amount of capital engaged and the mode of its employment. As raw material and coal can be cheaply obtained by sea, manufactures tend to develop, causing a further increase of wealth and population. This again reacts on the agencies engaged in collecting raw material and distributing the finished product Thus the seaport city tends to acquire an ever increasing momentum. New lines of railway are built to it, new lines of steamers make it a port of call, steadily increasing the prosperity which originally attracted them.

One more aspect of the interesting question of position may be noted. The greatest towns may have their vicissitudes, and unforeseen causes may for a time neutralise their indisputable advantages of position. A famous case is that of Genoa and Venice, which, in the early Middle Ages, were on the great highway between Asia and Northern Europe. The Turkish conquests in the fifteenth century interrupted this trade, and struck a deadly blow at their prosperity. The discovery of the Cape route transferred the advantage of position to the Atlantic ports, and Lisbon, Antwerp, Rotterdam, and the British ports successively secured the greater part of the world's trade. The cutting of the Suez Canal again made the Mediterranean the highway, and led to the rapid growth of Marseilles, Genoa, and in a lesser degree of Venice. There are those who maintain that its opening has been prejudicial to the interests of British ports, but this cannot be taken yet as proved.

The Drawing of Maps. The illustration on page 4514 shows three different maps of the world on which the British Empire is indicated by shading.

1. The Mercator projection is that most familiar. It has this advantage, that a straight line drawn between any two places on it represents the correct direction between them. It has many disadvantages. The size of countries is greatly distorted. Compare Australia, nearly 3,000,000 square miles, with Greenland, some 700,000 square miles.

2. To get rid of this distortion the oval-shaped map above it has been drawn. Australia and Greenland are shown in proper proportions. On it we may compare the size of different parts of the British Empire. Notice that the distance between the meridians at the equator is equal. The meridians of 90° W. and 90° E. of Greenwich form the circumference of a circle. One diameter of this represents the equator; the diameter at right angles, the meridian of Greenwich. The parallels are now drawn so that the area between two parallels is proportional in the scale of the map to the area between these two parallels on the earth. The equator and each parallel is divided into eighteen equal parts, nine west and nine east of the meridian of Greenwich, each representing 10° and numbered 0° to 90° W., and 0° to 90° E. Then the equator and each parallel is prolonged east and west until the distance beyond the circle is equal to that from the meridian of 0° to the circumference. Each part beyond the circle is divided into nine equal parts, numbered from 90° to 180° W., and from 90° to 180° E. The curves are now drawn through all points with the same numbers, and the network is complete. This equal-area, or equivalent projection, is called Mollweide's, and was invented in 1805.

3. The western and eastern hemispheres are not equal area projections, but the distortions are not nearly so great as in the Mercator projection.

Continued

DRAWING FOR SHEET-METAL WORKERS

Envelopes of Bodies. Plane Figures. Non-plane Figures. Projections. Pyramids—Right Figures. Pyramids—Oblique Figures

By JOSEPH G. HORNER

THIS course does not deal with problems in practical geometry, which are treated earlier. It only embraces the actual development of the envelopes of solid bodies. Although the problems involved in this subject are those of marking out with compasses, rules, and scales, more than this is required in order to translate these into practice. Joints of many forms occur continually, and suitable allowances have to be made for these beyond the edges obtained by the geometrical outlines. Then, again, allowances have to be made for some other matters which do not admit of exact calculation, and which have not been and cannot be formulated, but which can only come by experience in the shops. These include the influences of *bending, flanging, raising*, and allied operations in which sheet-metal undergoes coercion, so that its fibres move one over the other some being compressed, others extended. In very thin sheets the influences of these may be nearly neglected, but as sheets increase in thickness, as in the plates of the boilermaker, the results sometimes become puzzling to the workman. For actual metalwork is not like making a drawing that you may rub out and redraw. An error means a waste of valuable material, as well as of time.

Envelopes of Bodies. We will preface this article with remarks on the subject mentioned above as being a fundamental one—namely, the envelopes of solid bodies. That is the same thing as the envelopes of hollow bodies, with which all sheet metal workers are concerned. In other words, solids are enclosed by envelopes, the forms of which can be produced on plane sheets and wrapped around the solids, or enclose hollow spaces identical in form and dimensions with the solids.

We can here lay down two leading statements: (1) The shapes of the envelopes of bodies or of geometrical solids can in all cases be arrived at by the application of geometrical problems, combined with the principles of projection; (2) all these envelopes, of whatever form, can be obtained by the preparation and union of sheet-metal or alloy originally in plane forms, as sheet tin, copper, brass, zinc, iron, and steel, as used by tin and coppersmiths, zinc workers, and boilermakers. This is obvious in the case of *cubical* bodies, but the difficulties, real or apparent, exist when bodies are of *conical, spherical*, or *flaring* outlines, and when combinations of these occur, and junctions of various figures with each other. Frequently, when work such as hammering has to be done on sheets to cause them to assume other than plane surfaces, the number of joints has to be increased in thick plates more than is necessary in thinner sheets.

Joints. Next, with regard to the allowances for joints. The general rule is, first, to have as few joints as possible; next, to adopt the simplest joint that is consistent with efficiency. Within this range we have many kinds, from the simple union by soft solder to the treble-riveted, double-butted joints of the largest steam boilers.

The question of allowance for joints is not usually difficult, but it must not be overlooked. Generally, it involves a simple addition to the developed pattern of so much for overlap, or for wiring in some cases. In others, something more has to be considered, as when flanges have to be turned with more or less of radius, and when flanging has to be done in two directions on the same plate, as in the firebox sheets of locomotive boilers. Sometimes no allowance is made, as in thinned corners for boiler plates, or but little, as in the thinned edges of cramped joints. In butt joints, again, no extra is required. So that all through the work the craftsman who marks out must also keep in mind the methods of jointing as well as the allowances for puckering and drawing in concave objects.

Machine versus Hand Work. At the present time much of the work of the tinsmith and coppersmith has been appropriated by machinery, in which articles of steel are stamped at one operation or more, instead of being tediously marked out and shaped by hand hammering. But for all, except comparatively simple articles, the service of the worker in sheet-metals are still in request, and to all such a knowledge of drawing lies at the basis of the craft.

To those who are not familiar with this work it must sometimes be a matter for surprise how sheet-metal work is produced in such an infinity of forms. Neither is it all simple to the craftsman. But when difficulties arise, they are seldom those due to marking out the geometrical patterns, but they generally lie in the making of suitable allowances for raising by hammering processes. Generally, patterns, however elaborate in appearance, are composed of simple elementary forms in repetition, or in combination. It is, therefore, essential to grasp the elementary problems before attempting those examples which include combinations of the same.

Plane Figures. Considering in brief the forms of the envelopes of solid bodies, we see that large numbers of them have plane faces. These give us the first object lesson in our course.

Take any polygonal solid, and you see that by separating each side the figure really develops itself. As many sides as the figure possesses, so many individual planes will there be. Any

square [1] or oblong body would have six planes [2] for its envelope; top, bottom, and four sides. This may be made by cutting from a single sheet, as in 2, then turning up the four sides, and turning over the top; or each piece may be cut separately. A hexagonal body [3] would have eight planes [4]; top and bottom, octagonal in plan, and six sides, each of rectangular outline. This can be developed either as in 4, or as in 5, the relations of each of which to the body are obvious. The can with tapering sides, a prismoidal figure [6] is enveloped as in 7. The complete envelope [8] of an octagonal pyramid is a simple form. The envelopes of the sides have their lengths, A, equal to the *slant* height of the pyramid, and the widths, B, at the base are equal to the length of a side of the base. In obtaining the shapes of the envelopes in 1 to 8, the important point to be sure of is the dimensions of length and width, and correct angles—right and octagonal, and so forth. It is just a case of plain measurement with rule or compass.

The development of a truncated pyramid is shown in 9. The pyramid is first completed as indicated by the dotted lines, and then a length is marked off equal in length to the slant height required. The top and bottom octagonal sheets are exactly the same as those of a truncated pyramid in plan view. The construction in 9 would completely envelop the body.

In working out these, every face is a plane face, and the outlines are those of the faces looked at in a direction *perpendicular* thereto.

Slant Height. This manner of looking at a figure is of cardinal importance, as we shall see subsequently. It will occur continually in speaking of the *slant height* of an object - that is, the dimension taken along the plane of its face, instead of along the axis of the body. The two only coincide in figures having their sides parallel, as in rectangular and cylindrical bodies, and not at all in pyramidal and conical figures and those derived therefrom.

In working out many developments it is essential to bear in mind this difference in dimensions in the perpendicular and in the slant, or sloping portions of figures of which 6, 7, 8, 9, 10, and 11 are typical. Taking a pyramid for example, it hardly needs demonstration to show that the perpendicular height is different from the slant height. The perpendicular height is shorter, the slant height of the edge is longer, and the slant height of the faces is different from that of the edges. In obtaining the development of the envelopes of such figures, the perpendicular height has no permanent place. It is only used as an element in the work of development, but both of the slant heights are required for the cutting of the actual sheet of metal. The relations of these will differ considerably with the proportions of figures.

Non-plane Figures. Looking now at the envelopes of figures that are not plane, we see that bending has to be done. For a cone [10], the envelopes are a sector of a circle, and a circular base. For a conic frustum [11] they are a segment of a circle, and two circles for base and top respectively. For a cylinder [12] the envelope is one rectangular sheet bent to form the cylindrical body, and two plane ends, which are circles.

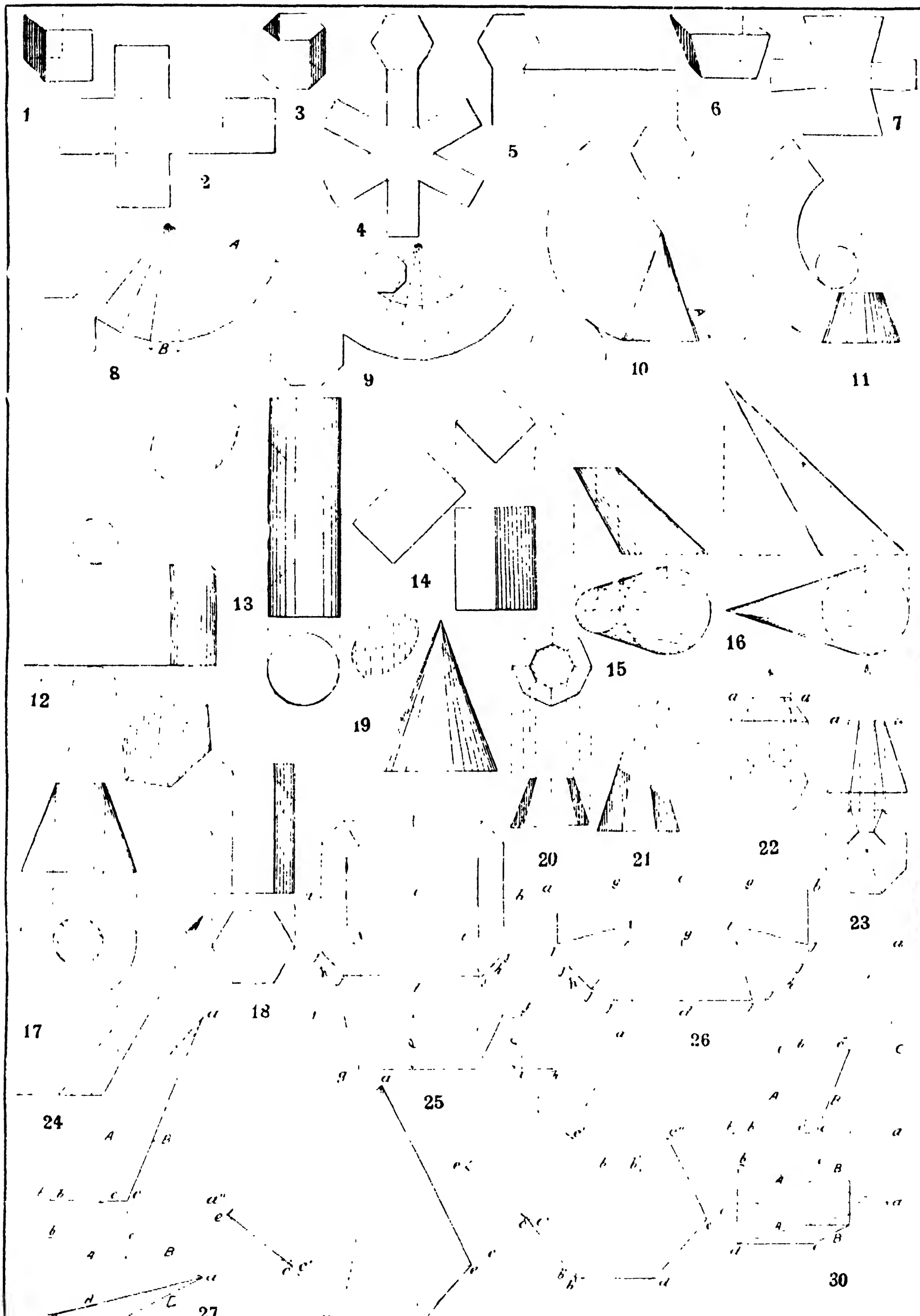
The envelope of a globe is a complete sphere also. But such bodies are formed by taking two circular discs and beating or pressing them to hemispherical shapes, or by preparing small pieces called *gores*, and bending and uniting them.

Methods of Bending and Hollowing. The question of bending and hollowing affects different trades in different ways. While a coppersmith easily hammers a sheet into a spherical form, the engineer has to bring powerful hydraulic machinery to do such work on steel plates. In the absence of such aids he increases the number of joints, and so lessens the amount of *dishing* required on a single sheet.

It might seem as though it would be easy to hollow a sheet of metal to any extent if the work be done at a high temperature. But such is not the case. In all work where metal or alloy is subjected to severe treatment, with much extension of its fibres, frequent annealings are necessary. To this rule there is no exception, either in thin sheets or in thick plates. Extreme examples are cartridge cases used for ammunition. These are drawn from solid sheets, but the work is spread over several stages with alternate annealings. It is in such work, of which this is an extreme though common illustration, that the shape and dimensions of the sheet cannot be obtained correctly by simple draughtsmanship, but previous experience of similar work is essential.

Projections. The drawing of the worker in sheets and plates is essentially that of projection, superadded to plane geometry. It is so, too, in engineers' drawing in general, but with this difference—the projections of the engineer are largely those of plans, elevations, and sections in directions perpendicular to each other. But those of the worker in sheets as often take place in planes perpendicular to sections taken at various angles with main axes. And what appears to the beginner to complicate matters is that many of the patterns of the tinman and coppersmith, zinc worker, and engineers' plater, are not symmetrical, or right figures, but are unsymmetrical, oblique, or slant figures, and these again have their projections of sections taken at various angles. And then, further, many objects of manufacture combine right with oblique figures, and portions of the envelopes of different groups of solids. If the separate sheets be not marked correctly they will neither joint correctly as separate pieces nor connect up to each other.

Once more, many cases arise in which, though it is known that an edge must be an arc of a circle, and though one could see how to strike it with compass or trammel, yet the radius is far too large to permit of this method. Then other devices are available, those of intersecting lines or of triangulation, by which accurate curves can be obtained step by step by constructive methods. And once the leading principles of development and projection are grasped, new problems are readily solved by a little thought.



ENVELOPES, SECTIONS AND DEVELOPMENTS OF BODIES

1. Cubical body **2.** Envelope of same **3.** Hexagonal body **4.** Envelope of same **5.** Alternative envelope **6.** Can with tapering sides **7.** Envelope of same **8.** Envelope of octagonal pyramid **9.** Envelope of truncated octagonal pyramid **10.** Envelope of right cone **11.** Envelope of conic frustum **12.** Envelope of cylinder **13.** Cylinder projected in end view and diagonal section **14.** Square figure projected **15.** Projection of oblique conic frustum **16.** Projection of oblique cone **17.** Projection of conic frustum **18.** Projections of hexagonal prism **19.** Elliptical section of cone **20.** Projection of truncated octagonal pyramid **21.** Projection of diagonal section of pyramid **22, 23.** Effect of differences in slant **24.** Oblique pyramid **25.** Octagonal tray **26.** Pattern for same **27.** Square oblique pyramid **28.** Development of same **29.** Development of oblique truncated pyramid **30.** Oblique truncated pyramid

Examples of Projection. Some elementary illustrations of the principles of projection, as they apply to the envelopes of bodies, will be of value before beginning practical problems. They are simpler in some respects than those which deal with projection as a whole, in which *thicknesses* are constantly occurring, because sheet-metal may be considered from this point of view to have no thickness, and therefore one surface—an exterior one—only has to be considered.

The sphere is the only object which appears the same from all points of view and in all sections. The same remark applies to the cube looked at perpendicularly to either face. In all other figures the projections are different.

A cylinder [**13**] has two external developments, that of the body [**12**] and that of the ends, circles. But if cut obliquely [**13**] its development is an ellipse. A square figure [**14**] shows plane faces if viewed perpendicularly to its sides, but angular faces if projected from the angles. An oblique conic frustum [**15**] has two projections, that of its circular base, and that of a smaller circle corresponding with the plane of truncation, besides the foreshortened plan view. An oblique cone [**16**] projected has the appearance shown; here, as in **15**, we see at a glance that the projected plans, being foreshortened, do not give actual lengths of the envelopes, which must be obtained on slant heights. A conic frustum [**17**] projected gives two concentric circles corresponding with base and top, and the slant in plan view. A hexagonal prism [**18**] has its true form projected parallel with the axis, but the equal-sided proportions do not appear if a projection be made perpendicular to a diagonal section. A cone has the conical form in elevation, the circle in plan, and the ellipse if cut diagonally across [**19**], besides the parabola and hyperbola if cut in other directions. The truncated octagonal pyramid [**20**] gives octagonal figures in plan, as shown, and tapering sides. The development of this was shown in **9**. An octagonal pyramid cut in oblique section [**21**] develops an irregular octagon.

The point to be noted in these figures is the alteration in form which the projections at different planes indicate. With every increase in angle there results an elongation of form, and when joints have to be made to fit at certain angles the importance of exact methods of development on the projected planes is obvious.

Simple Examples. We will now begin work on some of the simpler examples that arise. However varied are the shapes in which sheet-metal and plated work occur, they are reducible to a few elementary forms and combinations of the same. These are *parallelopipeds, prisms, pyramids, cylinders, cones, polygons, and spheres.* The prisms, pyramids, cylinders and cones may be right or oblique figures.

Pyramids—Right Figures. We may dispose summarily of parallelopipeds and prisms because the dimensions as well as the forms of their envelopes are obvious [**1** to **5**]. Right pyramidal forms are also simple, but some explanations are necessary here. A pyramid may be defined as a solid bounded by three or more triangles which meet at a point, and by the base, which is of polygonal form, having any number of sides. The height of the triangles must be taken on the slant lines, and a comparison of the two figures [**22** and **23**] shows how essential is the amount of slant in determining the forms of the triangular envelopes. If the pyramids be cut across the planes *aa*, we have truncated figures, and then the dimensions are required in the plane of truncation, and these are given by the projections in plan. In these figures each triangle, or wedge-shaped piece around the pyramids is like the rest, because the apex is situated perpendicularly over the centre of the base. But if located elsewhere, the pyramid is an oblique one [**24**], and the triangles are of unequal lengths, excepting those that correspond on opposite sides of the figure taken in the plane of the paper. The methods of marking out, therefore, differ in the case of right, and oblique pyramids, and, of course, of complete, and truncated pyramids, **8** and **9** respectively.

Truncated Pyramids. Complete pyramidal figures are seldom wanted, but truncated pyramids, or pyramidal frusta, and portions of the same, occur constantly, alone or in combination with other figures. Thus, taking one example by way of illustration, the pattern for a common octagonal tray with tapering sides is related to the truncated pyramid. Fig. **25** illustrates such a tray in plan and elevation, to be made in one piece, and though of polygonal outline, having small angular corners only. The centre lines, *ab* and *cd*, divide it at right angles; *e* is the vertical height of the tray. Lay out one half the *base* [**26**] to the same dimensions as in **25**, and draw through its centre, *c*, centre lines *ab* and *cd*. Draw centre lines, *hi*, *hi*, through the corners, corresponding with *hi*, *hi* in **25**. Now take the slant length *fg* [**25**] and transfer it to **26**, to *ag*, *bg*, and *dg*. Draw the lines, *aj*, *bj*, *dj*, *dj*, perpendicular to the main centre lines. Next take the lengths *aj*, *bj*, *dj* in **25**, and transfer them to *aj*, *bj*, *dj*, *dj* in **26**, which gives the lengths of the top edges of the tray sides.

To obtain the lengths of the corner pieces, project the vertical height, *e* [**25**], to the small diagram on the right; measure off the horizontal, or plan length, *ih*, in the upper figure and transfer to *ih*. Then the length of the slant line, *fh*, transferred to *hi*, *hi* in **26** will give the actual lengths of the corner pieces. Through *hi* the lines *jj*, *jj*, drawn at right angles with the centre lines *hi*, *hi*, will give the top edges of the corners. To get their length, measure off in **25**, *hj*, *hj*, and transfer it to *hj* in **26**, and draw the lines shown to the corresponding lines that give the bottom of the tray.

Pyramids—Oblique Figures. Taking now a few oblique examples, we must extend some of the fundamental facts already noticed as to the difference in perpendicular and slant heights of faces and edges.

Fig. **27** shows a square oblique pyramid, the development of which is shown in **28**. The

real lengths are not *ab*, *ac*, but the dotted lengths *ab′*, *ac′*, obtained by taking off the slant lengths in plan, *a′b* and *a′c* respectively, and transferring them to the upper figure from *a″*.

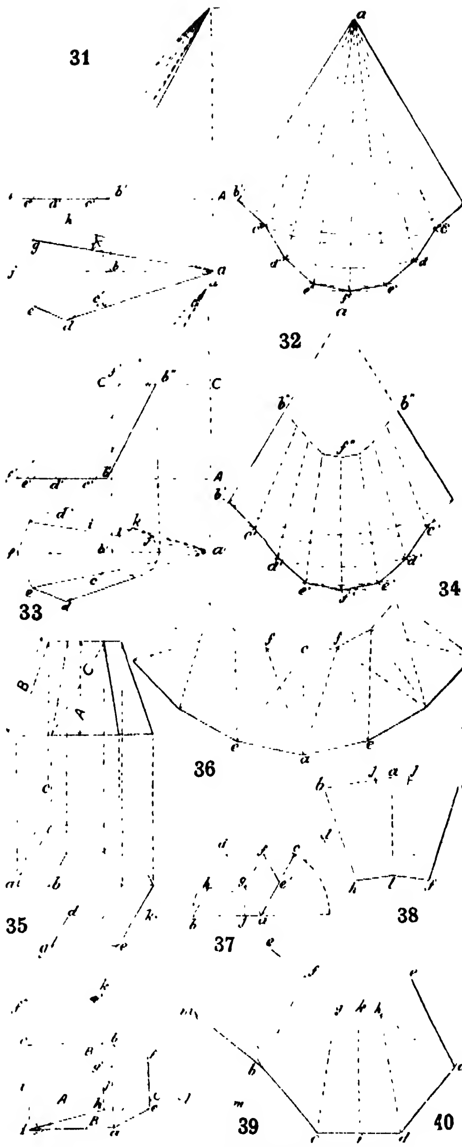
The development shown in **28** is obtained as follows: As the corners, A and B [**27**], have different lengths, measured from the apex, *a*, two radii are taken for these—the projected ones, *ab′*, *ac′*, and struck from *a* in **28**. Take the length of one side, *bc*, or *ce* [**27**], and set it off four times [**28**], cutting the radii just struck, starting from *ed*, thence from *db*, *bc*, and *ce*. Joining these intersections with lines, and also *ae*, and *e* at the extreme right and left, will complete the outline of the figure, while the lines dotted joining *ad*, *bc* correspond with the three angular corners of the figure, where the sheet-metal is bent from the solid. The seams will be added down the sides *ae*, *ae*.

Oblique Truncated Pyramids. The envelope of an oblique truncated pyramid [**30**] with square base is illustrated in **29**. The essential construction, so far as the base and the slanting corners are concerned, is exactly like that in **27** and **28**, and the same reference letters are retained, so that recapitulation is unnecessary. The top of the figure is determined by the cutting of the pyramid by the plane CC at a definite height, that of truncation.

Clearly, now, nothing more is necessary, having the complete pyramid already produced, than to take off a set of measurements on the plane CC, in addition to those on the base line. The set corresponding with the base of the pyramid is obtained first as in **28**, to which the same reference letters apply. The development of the top edge can be got either by taking lengths from *ab″*, *ac″* [**30**], or by measuring up from *b′b″* and *c′c″* [**30**]. With these remarks the construction in **29** is clear. The seams are added from *e″e* [**29**].

Oblique Pyramids. The oblique pyramid with octagonal base [**31**] resembles **27** in the manner of its development. It is necessary to have the base outlined correctly in plan, as in the lower portion of the figure. The real lengths of the slant angles of the corners of the figure are not the full lines in the elevation (upper figure), but the longer dotted ones adjacent, obtained by measurement from the plan view (lower figure), thus: *a′e*, transferred to A*e′*, *a′d* to A*d′*, and *a′c* to A*c′*, and the same lines, of course, answer for the length from *a′g*, *h*, and *i* respectively. The lengths A*b′* and A*f′* are the same as *a′b* and *a′f* below, because obviously these do not slant *away* from the observer, but only in one direction, that in the perpendicular plane.

To obtain the development in **32**, take the successive radii [**31**]—namely, *ab′*, *ac′*, *ad′*, *ae′*, and *af′*, and strike these radii in the manner shown in **32**; the seam in this case has to be added on the inner angle *ab′* of the pyramid, though not shown. Then take the length of any side of the octagon, as *bc* [**31**], and step that round six times between successive arcs, as shown in **32**, *b′c′*, *c′d′*, etc. Unite the points of intersection with straight lines, which, with the lines *ab′*, complete the boundaries of the enveloping sheet. The dotted lines from *a* to the points of intersection are the seamless angles where bending is done.



DEVELOPMENTS OF PYRAMIDAL BODIES

31. Octagonal oblique pyramid **32.** Development of san **33.** Truncated oblique pyramid **34.** Development of san **35.** Truncated pyramid to be developed by triangulatic **36.** Development of same **37, 38.** An alternative methc **39.** Oblique truncated pyramid to be developed by triangulation **40.** Development of same

The truncated oblique pyramid with octagonal base [**33**] requires little explanation, following the previous examples, which include the essential features in its development. The base of **33** is developed in **34**, as that of **32** is from **31**, the same reference letters being retained. The truncated portion is treated like that in **29** and **30** modified only by the difference in the rect-

angular and octagonal forms. A comparison of the reference letters in **29** and **30** with the instructions already given will render the construction of the developed outline in **34** clear, without repetition of details.

Pyramidal Figures, with Apex Inaccessible—Right Figures. Many cases arise in which the taper is so slight that the apex is, for practical purposes, inaccessible. We now, therefore, give attention to other methods adopted, by obtaining certain points in triangular figures, which can be best explained by a concrete example.

The method of triangulation is based upon the fact that the perpendicular height of A, and the slant height B [**35**], and the diagonal C, are mutually related, so that one can be obtained from the other. In this case, as in **25**, the slant height can be obtained by direct measurement. But if there were no elevation it can be got from the plan, thus:

The slant edge, *ab*, seen in plan, the real length of which corresponds with B in elevation, is taken as a base line. On this the perpendicular *bc* is raised, and upon this the vertical height *bc*, equal to the vertical height of *ab*. To obtain the length of the diagonal, C, draw the diagonal *de* on the plan view. On it raise the perpendicular *df*, and measure on that *df*, equal to the vertical height A of the pyramid, and draw the diagonal *ef*, which will give the true, or slant length of *de*; or C in the elevation. These lengths, *ac* and *ef*, are now employed to develop the envelope of the truncated cone thus: In **36**, *a* is a starting point in which the compass is set to mark the length of the slant height *ac*, taken from *ac* in **35**, and the length also of a side of the base *ae*, *ae*, equal to the length *ge* in **35**. The length *fe* of the diagonal face [**35**] is taken, and set off from *ce* and *e* in **36**. The lines *ae*, *ae*, will be drawn to intersect the distances *ae* with *ce*. From *e* and *e*, set off arcs *ff* equal in radius to *ac*, equal to B, the slant height of the figure **35**. Take the length *bd* of a side of the upper face [**35**], and set that off from *cf*, *f*. Draw lines, *cf*, *cf*, through the points of intersection. The remainder of the envelope is obtained by repeating these operations.

An Alternative Method. Another method, in which the essential development by triangulation is similar, is illustrated in **37** and **38**. In **37** a line, *ab*, is drawn equal in length to the base length of a side of the pyramid, and prolonged to right and left. From *a* as centre, and radius *ab*, describe a semicircle and divide it into half as many equal parts, by *c*, *d*, as there are faces to the pyramid—three for a hexagon, four for an octagon, etc. Draw the line *ac* through one of these points of division; *ab*, *ac* now represent the lengths of two base lines and *cab* is the angle which they make. The length of the bounding lines on the upper or smaller end of the frustum of the pyramid is obtained by setting off the length of a side from *ae*, and drawing a line *ef* parallel with *ad*. From *f* the line *fg* is drawn parallel with *ae*, and *fg* is the length of a side on the smaller end; *gh* being drawn parallel with *ab*, and equal in length to *gf*, gives the length of the side adjacent. The figure *bacfgh* is a plan view of two sizes of the figure required, but it does not as yet give the slant height of the sides and edges. These are obtained by the triangulations of the previous figures.

To obtain the slant height of the faces, let fall a perpendicular from *gj*, set off *jk* equal in length to the perpendicular height of the frustum of the pyramid. Then the length *kg* will give the slant height of the face, indicated in plan by *gj*. To obtain the slant height of the edges, draw *gl* perpendicular to *ag*, and equal in length to the perpendicular height *jk*. Then *al* joined will be the slant height of the edge *ag*.

The developed pattern [**38**] is obtained thus: Draw the line *al* equal in length to the line *al* in **37**. Then from *a* as centre, and radius *aj*, set off the arcs *j*, *j* in **38**. With *l* as centre, and radius equal to *kg* [**37**], draw arcs intersecting *jj*, at *jj*, and draw lines from *a* through these points, prolonging them to *b* and *c*. Measure the length *ab*, *ac*, equal to the lengths *ab*, *ac*, and *lf*, *lh*, equal in length to *gh*, *gf*, in **37**, completing the development of two sides of the required frustum.

Pyramids—Oblique Figures. If, for any reason, a truncated oblique pyramid cannot conveniently be developed to the apex, as in **39** and **40**, triangulation is available which we have just applied to right figures. Fig. **39** illustrates, we will suppose, such a pyramid in plan, and of which we know the height of the figure. A line *ij* is drawn on the front slant, and on it another, *jk*, is raised, equal in height to the height of the figure. The diagonal, *ik*, then equals the slant height of the frustum on the outer face A. For the slant height of the faces B, draw the diagonal *bg*, on it raise the perpendicular *gl*, also equal in height to *jk*. The diagonal *bl* then equals the slant height of the faces B and B. To obtain the slant height of the face C—that is, the face bounded by the corners, *a*, *b*, *e*, *f*—draw the diagonal *af*, on it raise the perpendicular *fm* equal in height to *jk*, and the diagonal *am* will equal in length that of the slant face C.

The development is shown in **40**. Draw a line *ik* equal in length to *ik* in **39**, and draw two lines at its terminations at right angles with it. On these lines set off the lengths *cd* and *gh*, corresponding with those in **39**. Take the diagonal *bl* in **39**, and strike radii with it from *gh* [**40**] to *ab*. Measure the length of the sides, *ad* and *cb*, and strike radii with these, cutting those just struck at *ab*. Join *ad* and *cb*. Draw *eh* parallel with *ad*, and *gf* parallel with *cb* and equal in length to *gf* and *he* in **39**. Take the diagonal *am* in **39**, and strike an arc from *fm* [**40**]. Draw *bm* of length *cd* to intersect, and draw *fe* parallel with *bm*. The lines *me*, *ae*, will complete the boundary of the pattern outlines, and the dotted lines *bf*, *cg*, and *dh* are the angles for bending.

Continued

THE NATURAL MAN

The Three Aspects of Man. Perfect Health. The Effect of Occupation. The Great Gain of Life in our Generation. Town Life and the Death Rate.

By Dr. A. T. SCHOFIELD

THE normal man, like "the average man," is a being often heard of but seldom seen, because he rarely exists. Like pure air or pure water, he is supposed to be a commonplace, whereas in reality he is a great rarity.

There seem to be sound psycho-physiological and even anatomical grounds for the tripartite division of man into spirit, soul, and body. The brain itself has naturally a threefold division anatomically, as pointed out by Dr. Hughlings Jackson. There is the cortex or surface of the brain in hemispheres, the mid-brain, composed mainly of two great masses respectively concerned in motion and sensation, and then there is the third and lowest—the medulla and upper part of the spinal cord. That these three regions are broadly connected with three parts of man is shown by experiments on frogs and pigeons. It is found that a pigeon from which the cortex, or seat of the intelligence, or spirit, has been removed can still perform all the functions of animal life and physical existence, but it has lost the directing, guiding intelligence. It flies, but cannot direct its flight, and acts more or less like an automaton. If the mid-brain be removed, the animal life goes, and bare existence remains. The bird can no longer fly or seek food, but if fed, can exist.

The Three Parts of Man. We may thus anatomically and physiologically and psychologically say that with the cortex we *live* (spirit life), with the mid-brain we *move* (animal life), and with the medulla we *exist* (body life), or, in the words of the great Christian apologist on Mars Hill, "In Him we *live* and *move* and have our *being*." A man, therefore, must be regarded as a tripartite being. While mainly concerned with physical health, we seek to give due weight to intellectual and moral health, and, taking a broad view, deem no man in health whose spirit or soul is sick, though the body may be sound.

"In good health," says one well-known hygienist, broad enough to survey man as man, "there must be the capacity and desire for every kind of prolonged physical exertion with skill, ease, and pleasure. But this is not enough. There must be the capacity and desire for every kind of prolonged intellectual exertion with skill, ease, and pleasure. But this is not enough. There must be the capacity and desire for every kind of prolonged spiritual activity with skill, ease, and pleasure, and there must be evidence that all three divisions are in health."

Not that the three divisions are equal. Mr Eustace Miles has graphically shown their true relations somewhat after this manner:

In health, spirit controls the soul, which controls the body.

In ill-health, body controls the soul, which controls the spirit.

In other words, a strong body obeys the mind, a weak one rules it.

The Healthy Man. In full health a man lives as simply and cheaply as he can. There is self-control and purity, patience, candour, altruism, contentment, and happiness. He is healthy in all circumstances, and, even if the balance be upset by bad environment, the healthy man soon unconsciously compensates, and the balance is restored with ease.

Health, it has been well said, is a constant equilibration rather than a constant equilibrium—that is to say, there are daily variations, and constant oscillations, and not a fixed condition. Health is like a block of wood with many sides; so that whichever way it is pushed over, it stands equally well. The healthy man controls his circumstances, and is not controlled by them. Ideal health is largely independent of conditions. The athlete is not a healthy man, nor the student, nor the saint. Each one has a tendency to develop one part of himself at the expense of the other two. The recent development of colour photography is a good illustration of this. There are three colours in nature, as there are three parts in man, and any scene that has to be photographed in colours has to have three exposures, each one made by cutting off two-thirds of the light, which, of course, is itself made up of all three colours. These exposures are then printed in red, yellow, and blue, and when one is shown on a screen we get the landscape in shades of red, when the yellow is superimposed we get the orange and yellow tints added, but all is glaringly unlike Nature. But the moment the third part, the blue, is added, all falls into perfect harmony, and we get the browns and greys, and all the subdued half tints of Nature herself. So with man: it is not until we get the three parts—spirit, soul, and body—superimposed, and all in healthy development, that we can see and know what is a true man.

The Physical Man. What, then, is a human being physically? If a man, he is, in the perfection of civilised life in this twentieth century, an individual six feet high, weighing thirteen stone. In certain manufacturing districts he is only five feet one and a half inches, and averages seven and a half stone in weight. All averages, however, are being now constantly exceeded, and must soon be raised. At birth, if a man, he will now expect to live only for 45 years, if a woman, for 47 years, although it is believed that his full span of life should be 105, or five times the period of his growth. He is essentially a unity, and yet a unity in diversity.

A Unity in Diversity. It will, of course, occur to all that he is a trinity in unity, a compound of body, soul, spirit, and yet but one man, one personality. A collection of divers machines of complex structure, and constructed of heterogeneous materials, all crumbling away at different rates, he yet moves, and acts as an independent unit, governed as regards the life of his body by the one unifying factor, the unconscious mind; as regards its actions by his conscious mind, the two forming but one mind, one character, one ego, and the whole, with the body, forming one person—man.

This man, if he survives the first two or three years of his life, will probably live to 75 instead of to 45; and his life would then be divided into three stages of about 25 years each, the first being *growth*, the second *maturity*, and the third *decay*.

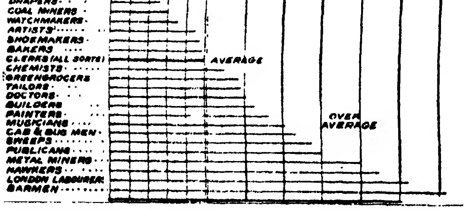
The height and minimum weight of those men who do not reach the high standard of six feet and 13 stone, if in perfect health, are as follows:

5 ft. 6 in.	= 10¼ stone.	5 ft. 9 in.	= 11½ stone.
5 ft. 7 in.	= 10½ „	5 ft. 10 in.	12 „
5 ft. 8 in.	= 11 „	5 ft. 11 in.	= 12½ „

The points to look for in man are height in relation to weight, perfection of movement, and sensation.

The Slaughter of Life. As to physique, it must be remembered that the measurements we have given are far in excess of those of ancient times, for the race is supposed to increase, as we have already said, in stature in civilised countries at the rate of 1¼ in. in every 1,000 years. Not only so, but, low as the average of 45 years out of a possible 105 may appear, it is really a very great advance over that of 36 in the early part of the nineteenth, or 20 in the eighteenth century, and is mainly due to the increase of private and public hygiene everywhere. It is probably an understatement to say that hygiene saves now some 120,000 lives every year. And yet to-day the needless mortality amongst infants (some 50,000) is terrible and shameful, for the low average of 45 years is mainly due to the enormous infant mortality that persists. When all babies under six months old drink nothing but clean milk infant mortality will at once be reduced by one-half.

Occupation has a bearing upon the health and longevity of the man, as this table shows:



It will be seen that clerks of all sorts are the only people who live the right time according to the present average: that is, that they die at the rate of 100 per cent., and at 45 years of age.

Why People Die. The clergy head the list and live nearly twice as long as the average. They come of a good stock, are temperate in habits, and have a small but assured income. Free Church ministers die a little faster. Farmers live long, but would show up better if they spent less money in drink. The agricultural labourer's favourable lot in life (only three-fourths of the average death-rate) is all the more striking when contrasted with that of the town labourer (the lowest but one), who dies just twice as fast as he should. Grocers owe their higher death-rate to the spirits they consume. Lawyers are well off, but it is found that after 45 they die off more quickly than they used to do, probably from increased strain of life.

Drapers die mainly from consumption, owing to the amount of dust in their trade, which makes it less healthy than that of a grocer. The health of coal miners, which is surprising, is probably due to the fact that only strong men enter the colliery, and to the harmlessness of coal dust. Artists owe their higher mortality to the fact that with them are included engravers and sculptors, among whom the death-rate is high. Bakers die usually from drink and suicide. Clerks occupy the average, as we have seen, and their death-rate is much lower than it used to be, owing probably to better ventilation of offices and increased exercise.

The table ranges from the clergyman, with a mortality of 55 per 100, to the pot-boy, with 220—a difference that needs no words to show the value of hygienic influence. Nevertheless, as a whole, this table, composed in 1885, shows an improvement over previous ones that is equivalent to an addition of 2,000,000 years of life annually to the nation. Since then the improvement has continued steadily.

The Perfect Man. A man "in order" is, then, as a whole, one free from disease, functional or organic, whose weight bears a certain relation to his height and general physique; who leads a healthy life, and pursues, if needed, some healthy calling; who is temperate in all things, avoiding intoxication, physical, mental, or moral; who gives due balance of work to both physical and psychic natures; to whom every morning is a resurrection, and whose life is one of perfect personal ease and action both in mind and body. All his three natures are in perfect harmony, so that internal discord is unknown; and lastly, but above all the rest, he is "in tune with the Infinite."

The personal appearance of this man will be the mean between fat and thin; his shoulders will be broad; his hips lean; his chest well developed; his hair probably brown in this country—for, comparing the proportion of the different shades of hair, there are about eight brown to every six either light or dark brown, or four fair, or two either black or flaxen, or one red. He will have a clear, bright eye; a frank, noble, pure expression; a clear, soft, unwrinkled skin; elastic arteries, with good heart, lungs, and liver, good digestion, and perfect sight and hearing.

Manhood in its perfection may be said to extend from 25 to 55 years of age, the whole of which time should be a period of perfect health, equally free from the dangers and diseases attending youth and growth on the one hand, and those attending old age and degeneration on the other. Absolute perfection may be said to be attained about 40.

Marriage and Health. The best time for marriage is—for woman, from 21 to 28, the limits being 20 to 35; for a man, 28 to 35, the limits being 24 to 40. For a happy marriage there should be some contrast between the pair, but not too great a difference in tastes, position, temperament, age, size, and race. Neither should be seriously diseased, and if healthy up to the age of marriage, the fact of being the offspring of diseased parent or parents is not a sufficient bar to union. The marriage of healthy cousins is sometimes detrimental in one generation, but, if persisted in for several, results in a dwarfed and deteriorated race. A town dweller of three generations should certainly marry into a country stock. The health of the parents is of the utmost value to the offspring. Hence nerves should be kept in order in married life, not only for selfish, but for altruistic reasons. All ex-excesses of body, soul, or spirit should be carefully avoided, and moderation and temperance in all things should be practised. When the food is scanty and poor, boys are likely to preponderate; where plentiful and generous, girls are most numerous.

Marriages are not so fruitful if the man is younger than the woman, or more than 16 years older. The boy and girl unions amongst the less educated are the great cause of the infant mortality. A woman reaches her perfection at thirty-five years of age, a man at forty. At this period of life many of the rules of hygiene have to be radically changed. As long as the body was growing one could hardly eat too much food, but now abstinence is the rule, and the weight once fixed should be by no means exceeded.

The table on this page gives the approximate weight of men, women and children at different ages (clothes average 7 lb., or 6 lb., without shoes).

With regard to food, the majority of us eat too much. A man should be most strict not to exceed his settled weight as shown by the scales.

What we Should Eat. It is well to eat a good breakfast, a good luncheon, and a plain and somewhat scanty dinner. Both the digestion and assimilation get weaker as the day goes on. The French breakfast at twelve or one o'clock is too late for English habits, and the early roll and coffee is not enough by itself to do a morning's work on. It has been found that on the coffee and roll a French workman does only some 250 to 300 foot-tons of work as compared with the Englishman's 500 on a better breakfast.

But it is not only the habit of eating too much that has to be resisted at this age: there is the question of drinking. Strict moderation is increasingly imperative in the wear and tear of modern life, and a very careful watch should be kept against the growth of any habits at this period; for it needs but one or two evil ones to wreck fatally the most promising life.

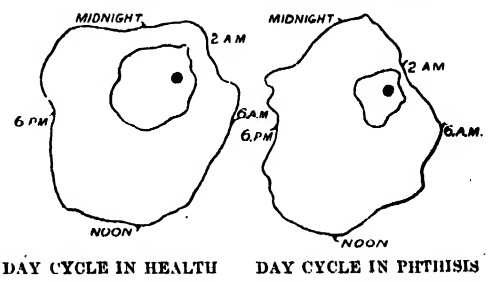
All Classes.				Boys. Upper Classes only.			Girls. All Classes.	
Height.	Women (with clothes)	Men (with clothes)		Age.	Height.	Weight.	Height.	Weight.
ft. in.	st. lb.	st. lb.	Chest Measurement.	Years.	ft. in.	st. lb.	ft. in.	st. lb.
4 10	7 0	..		4	3 2¼	3 2	..	..
4 11	7 4	..		5	3 5	3 8	3 5	2 12
5 0	7 7	8 0	33½	6	3 8	3 12	3 7½	3 1
5 1	7 12	8 4	34	7	3 10	4 1	3 9½	3 5
5 2	8 2	9 0	35	8	3 11	4 3	3 10½	3 10
5 3	8 9	9 7	35½	9	4 1¾	4 6	4 0½	4 1
5 4	9 2	9 13	36	10	4 5	4 11	4 3	4 6
5 5	9 9	10 2	37	11	4 6½	5 2	4 5¼	4 12
5 6	9 13	10 5	37½	12	4 8½	5 10	4 8	5 6
5 7	10 8	10 8	38	13	4 10½	6 4	4 10	6 4
5 8	11 4	11 1	38½	14	5 1	7 1	5 0	6 12
5 9	-	11 8	39	15	5 3½	7 12	5 1	7 8
5 10	—	12 1	39½	16	5 6½	9 2	5 1½	8 1
5 11	—	12 6	40	17	5 8	10 1	5 2½	8 3
6 0	—	12 10	40½	18	5 8½	10 6	5 3	8 9
6 1	—	13 0	41	19	5 8¾	10 8	5 3½	8 12
6 2	.	13 7	41½	20	5 9	10 12	5 3½	8 12

As to dress, a flannel belt is of value, and is a protection in many ways. It must be remembered that fat does not lessen the risk of taking cold but rather increases it.

Bathing in ice-cold water is not advisable after 35 or 40, but the coldest water is always safe when standing in hot. The hair should not be constantly wetted, as this tends to baldness; but the whole body should be bathed every day, and washed with soap once a week.

The bodily powers, as measured by the force of respiration and circulation, vary very much in the twenty-four hours, and there can be no doubt that two o'clock in the morning is the weakest time of the twenty-four. It is the hour of most births and most deaths.

These diagrams show the varying force of respiration and circulation through the day:



DAY CYCLE IN HEALTH   DAY CYCLE IN PHTHISIS

In these diagrams the dot represents death or the stoppage of life; the inner line is that of respiratory force, the outer the circulatory.

The life should be conducted so that there is neither gain nor loss, but an even weight for

30 years at least. A long journey every day by train is certainly bad, and a great strain on the nervous system. For sedentary occupations it is of great value to be able to walk to and from business. If there is difficulty about going to sleep at night a good plan is to rise half an hour earlier each day until you go to sleep as soon as you go to bed.

The Three Dangerous Ages. Avoid all irregularities and excesses, strains on the heart, worry, loss of sleep and obesity. There are said to be three periods when one is prone to sickness—at 36, when the lean tend to get fat, and the fat lean; from 45 to 50 the climacteric; and at 61 another crisis occurs, when the powers of life may suddenly fail.

In spite of the rush of people from country to town, in spite of the enormous size of London and the growth of all our cities, every generation at the present day lives in the aggregate millions more years than in the "good old times."

The difference between the present time and fifty years ago may be well shown. Out of a million men born 62,000 are alive at 20 years of age who would then have been dead; at 50 the same number; while even at 70 we have over 15,000 to the good. Surely this shows the solid value of health laws in adult life!

It may be said that in this country, at the age of 20, over 2,500,000 people are living now who, 50 years ago, out of a similar number of the same age, would have been dead; and when we know that each person on an average is said to be worth £156, this represents an addition of nearly £400,000,000 to the assets of the nation. So that hygiene pays its way

We are constantly being warned of the ill effects of the present rush of life. Diseases of the nervous system are increasing, and diseases of heart and lungs and liver are rife; but zymotic diseases are much fewer, so that we die now more from wearing out some part of the body than by a premature poisoning by germs.

Town Life and Health. On the whole, life was never so safe from fatalities as at present. At any single year up to 79 there are more survivors out of any given number than formerly; but, curiously enough, over this there are fewer, and this is said to be mainly due to the modern preference for town life. The increase of mortality due to this cause is amazing If a labourer comes to town he takes, on an average, 20 years off his life. At 65 years of age, out of 100,000 persons born, nearly 20,000 more are alive in the country generally than in a large town.

As hygiene lengthens our days, we cut them short by our town lives; and it would be greatly to be regretted if mere length of life represented the greatest desideratum. But this is far from being the case, and, doubtless, a large number of those who spend their years in town can show how much they and others have benefited in other ways even if they have lost somewhat in length of days. There is, however, a far better prospect for healthy manhood than there ever was before; for not only are the years longer, but they are much more healthy and more enjoyable. There can be no doubt that the modern appliances for saving time and wear and tear have greatly lessened the evils produced by the greater rush of life.

Care of Old Age. Now, as to the care of old age, the chief points are moderate and digestible food, sufficient warmth, and an even and quiet life. The chief of the three is the food, or fuel for the lamp of life. While all fixed dieting is bad where it can possibly be avoided, a few hints can be given that may prove of value. The older a person is after 50, the less food he requires. Luigi Cornaro, who lived to 100, though of a feeble constitution, took 12 ounces of solid food and 14 ounces of fluid daily during the latter part of his life; and his most severe illness was caused by his increasing his allowance, through the continual entreaties of his friends. Very little proteid or animal food is required, and though in many respects false teeth are a great boon to the aged, they may lead to too great a consumption of animal food. It is not the amount of coals we put in a grate that warms the room, *but the amount that can be burnt;* and the great point is to avoid choking the digestive and excretory organs with excess of food. The food of the nursery is the best in old age. Bread-and-milk and honey is a capital diet. Milk agrees with nearly all. Hot milk with a little Mellin's Food forms an admirable drink at night, and can be kept warm in a hot water jug covered with a cosy. Fruit is wholesome if ripe or well cooked. Fat, as cream or fresh butter, is good. Warm food is very suitable. Soup enriched with cream or marrow is light and nourishing. All meals should be regular, and all excesses avoided. If weight is being gained the diet should be decreased. In addition to the after-dinner nap, as years creep on, a doze after breakfast and before dinner is often helpful.

Clothing and Warmth. Clothing should be both warm and light. The underclothing should be of wool. Fur is an admirable material. A sealskin waistcoat is useful, and the feet and hands should be well and warmly clothed. An eider-down quilt on the bed, which should be warmed in winter, is a good covering. No aged person should be suffered to get cold in bed. The warmth of the bed is of great importance in old age. A warm bath should be taken every day, and a warmer bath, with plenty of a pure mild soap to keep the skin supple and soft, should be used twice a week. It is better for old people who have the opportunity to winter in the South of Europe, if possible. If not, the aged should shut themselves up in a well warmed house at this season.

The rooms should be at a temperature of 65° to 70°. The habits of old people should not be lightly altered. Whatever excites exhaustion should be forbidden; early rising is, therefore, bad. Hard drinking-water is not good, as it tends to hasten the calcareous changes in the body. A fixed diet should not be rigidly adhered to: variety is often essential.

Continued

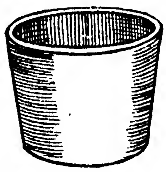
GLASS AND GLASS-MAKING

Nature and Properties of Glass. Manufacture of Glass Pots. The Furnaces. A Series of Recipes. Annealing and Hardening. Crown and Sheet Glass

IT is not within the scope of this article to trace the history of the manufacture of glass. It will suffice to note that the first window glass was made in England at Crutched Friars, London, in 1557, and fine articles of flint glass soon afterwards at Savoy House. The first sheets of blown glass for looking-glass and coach windows were made in 1673, at Lambeth, by Venetian workmen. The abolition of the Excise duties on glass, in 1845, may be considered the starting-point of the modern glass industry in England, which at once expanded into an enormous trade.

What is Glass? Glass may be defined as a non-crystalline, transparent, solid substance produced by melting at a high temperature *silica*, or a similar body, with an *alkali*. In place of silica *borates* and *phosphates* have been used, and the term *alkali* must be taken in its most elastic sense to include alkaline earths such as lime and baryta.

It is usual to regard glass as insoluble in water, although it is not so, strictly speaking, infinitesimal amounts being soluble. Alkaline solutions have a slightly greater solvent power on glass than water, but acids act but little on glass with the exception of hydrofluoric acid.

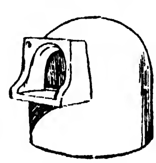


1. OPEN POT FOR PLATE AND SHEET GLASS

Age and Weather Affect Glass. The weathering of ancient glass in cathedral windows is due to the decomposing action of atmospheric moisture, and a special "disease" of old glass has been traced to a fungoid growth. The iridescence of old glass is due to exposure to moist air or damp earth for long periods. Sir William Crooks has traced a curious lavender coloration of glass to the action of ozone in the air. The brittleness of glass will occur to the reader as one of its most characteristic features; but curiously enough, glass drawn out into fine threads is quite flexible, and a mixture of glass and silk has been used to make a fabric of exquisite sheen. When hot glass is rapidly cooled it often breaks, because it is a bad conductor of heat. The exterior surface of the glass cools more rapidly than the inner portions, unequal contraction and usually fracture resulting. The thinner a glass vessel is the less liable it is to break. It is quite usual for chemists to put boiling water into thin blown vessels without any untoward results; but as soon as thick-walled vessels are submitted to similar treatment trouble begins. When newly-made glass is allowed to cool quickly great tension is put upon the various strata of glass so that if such a vessel be scratched it flies to pieces. This effect of tension is overcome by cooling glass slowly, the whole process being known as *annealing*. Glass is impervious to gases and is a bad conductor of electricity.

Glass Pots. The crucibles in which the glass materials for making pots are melted are made of fireclay and require the greatest care in the manufacture, as imperfections lead to fracture of the pot and consequent waste of glass. In Great Britain the most famous fireclays are those from Stourbridge and Glenboig, near Glasgow. Other famous fireclays are obtained from Forges-les-Eaux in France, Namur in Belgium, Sargenau in Switzerland, and Schwarzenfel in Bavaria. In the United States the Missouri plastic clays are chiefly used. The composition of fireclay is mainly silica and alumina combined with a small percentage of water, which last-named, being expelled in the drying and annealing process causes a considerable amount of shrinking in the pot.

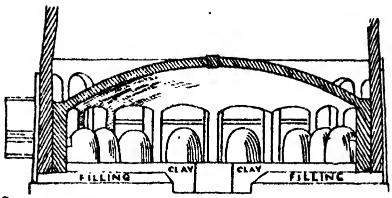
Preparing Fireclay. The virgin fireclay is carefully picked over to remove impurities, dried, ground, and sifted. To counteract the shrinking of the pots a proportion of old glass pot or ground burnt clay is always mixed with the raw fireclay. A mixture such as the following is used: Ground pot scrap, 3 parts; ground burnt clay, 4 parts; ground raw clay, 6 parts. These ingredients are carefully mixed and sifted and measured into a lead or zinc-lined trough. The mass is then damped with water, allowed to stand for two days and kneaded. This kneading is accomplished by workmen trampling in the clay from side to side of the tank, the warmth and elasticity of the naked feet being considered better for developing the plasticity of the clay than the pug mill sometimes employed. The treading is repeated at intervals, some months being allowed for the material to mature. There results finally a dense plastic clay from which the pots are fashioned. The workman makes the clay into rolls, taking care that no air cavities are left, and begins modelling the pot on a board or stone covered with granulated pot scrap or burnt clay. The roll of clay is laid in a spiral manner, the edges being scored to promote adhesion of the separate layers, the bottom and sides of the pot being in this way gradually built up. The two kinds of pots are illustrated in 1 and 2, the former being the open pot used for plate and sheet glass, the covered pot being the kind used for flint glass-making. The drying of the pots is very carefully regulated, the process occupying from four to 21 months. The final process consists in annealing the pots by heating them for a few days gradually



2. CLOSED POT FOR FLINT GLASS

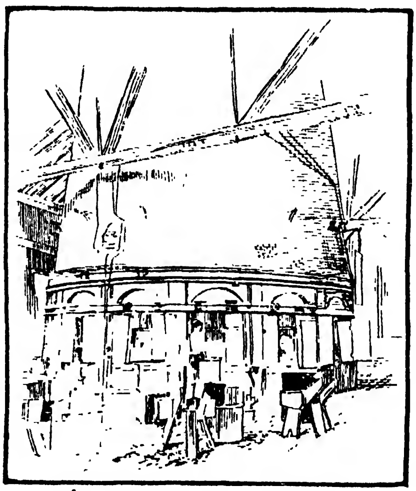
to red heat and glazing. The interior of the pot is glazed by throwing in a quantity of broken glass just before use. The coating thus given protects the clay from the action of the alkali used in meltings.

Melting Glass. Glass is melted in a modified form of reverberatory furnace, gaseous fuel being employed. The furnaces are constructed upon the general principles of obtaining the most intense heat possible, regularity in maintaining this heat, and economy of fuel. Silica bricks, which are quite infusible if kept free from alkali, are used for the most exposed parts of the furnace, but fireclay bricks of the most refractory kind are the general material of which the furnace is built. The fireclay is mixed with ground flint before being made into bricks, and the bricks are used without previous drying. The bricks are bound together with iron. After building, the furnace is left to dry for some months, and then the drying is completed by firing. A furnace lasts from two to five years.



3. SECTION OF GLASS-MAKING FURNACE SHOWING MELTING-POTS

The Furnace. The older dome-shaped type of furnace [4] consists of two parts the combustion chamber and the *cave* or draught chamber beneath. Between the two, in the centre, is the grate, which is sunk a few feet below the *siege,* or bench upon which the glass melting-pots are placed [3]. From 4 to 18 pots are accommodated on the siege, and they are reached for working or charging by a small arched opening situated directly over each pot. In the case of the covered pots used for flint glass the mouth of the pot is exposed on the outside of the furnace walls. The combustion chamber is surmounted by a low flattened arch for the purpose of reverberating the flame. The products of combustion are led by means of short flues situated beside each of the pots into the large chimney surmounting the furnace. A double-arched roof is arranged in some kinds of furnace. The draught needed to promote combustion of the small coal is obtained by means of the cave, which is frequently arranged in two passages at right angles, so that advantage can be taken of the direction of the wind. As a good deal depends on the regularity with which the fuel is supplied, mechanical feeders are employed. The Boetius furnace is an improved type of this furnace, in which heated air is introduced with the gas obtained by heating coal. These furnaces are also constructed in connection with a Siemens regenerator, the air and gas entering through the bench of the furnace within the circle of pots.



4. GLASS-MAKING FURNACE

The Siemens Furnace. In 1861, C. W. Siemens and F. Siemens obtained a patent for a glass furnace in which regenerators are applied to receive the waste heat of the products of combustion and conduct it to the air needed for supporting combustion. The solid fuel is decomposed or gasified in a separate apparatus, and heated to a high temperature before it enters the glass furnace. Since then, notably in 1870 and 1872, further improvements have been patented.

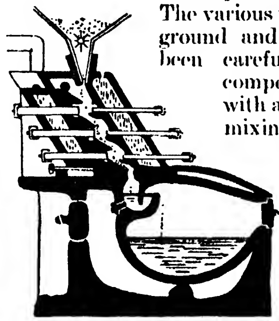
The Siemens type of furnace is now very general, but has been altered in many ways since its first introduction. The gas producer, for instance, is now made as part of the furnace, and the expense is lessened, because the regenerator is omitted.

In the newer furnaces the ordinary glass melting-pots are replaced by tanks, and as the melting is generally continuous, great economy of fuel is effected over the older kind. There is also an intermittent type of tank furnace which is necessary for some kinds of work. In the continuous tank furnace a capacity of 12 to 20 tons each 24 hours is usual, such a furnace being worked with two shifts of men. A furnace of this description, having a capacity of 12 tons, uses about 8 tons of bituminous gas coal each 24 hours, the 12 ton production being the net product over and above all waste and breakage. The furnaces are more durable than the old furnaces, because in keeping up the heat the firebricks are not so strained by being subjected to grêat changes of temperature.

Electric Furnaces. Many attempts have been made to use the heat of an electric arc for melting glass materials, two of the most promising electric furnaces being figured in 5 and 6. In the Voelker furnace [5] the hopper feeds the material, which passes in succession between carbon arcs. Direct current generated by a 360-ampère dynamo with a voltage of 120 is passed through the carbons. The intense heat of the first arc melts the raw material and causes it to trickle downwards, bringing it under the influence of the second arc, and then of the third arc. The melted glass collects in the cup beneath and thence into the large reservoir free from gases and impurities. It is claimed that with this

furnace bottles can be blown within half an hour of charging the hopper. Referring to the illustration of the Becker furnace [6], the three small circles represent the carbons, the passage of the raw material being indicated by the dotted lines. From the left-hand tank the melted glass passes over a bridge into the right-hand side and is free from bubbles of gas and ready for use.

Glassmakers' Recipes. The following standard recipes for making various kinds of glass are intended to give a general idea of the proportions of materials employed. In practice the number of recipes is very great, different makers preferring certain mixtures of ingredients.



5. VOELKER'S ELECTRIC FURNACE

Crown Glass. 1. Silica (sand) 600 parts; chalk, 65 parts; sodium carbonate, 400 parts; cullet (broken glass), 500 parts. 2. Silica, 400 parts; quicklime, 64 parts; sodium sulphate, 200 parts; charcoal, 16 parts.

Window Glass. 1. Silica, 120 parts; potassium carbonate, 60 parts; arsenic, 1 part; borax, 2 parts. 2. Silica, 100 parts; chalk 25 parts; sodium sulphate, 35 parts; cullet, 100 parts; arsenic, 1 part; charcoal, $1\frac{1}{2}$ parts; manganese oxide, $\frac{3}{8}$ part.

Plate Glass. 1. Silica, 400 parts sodium carbonate, 250 parts, chalk, 30 parts. 2. Silica, 100 parts; quicklime, 12 parts; potassium carbonate, 6 parts; sodium carbonate, 33 [illegible] cullet, 100 parts; manganese oxide, [illegible] part; pota[illegible]m nitrate (nitre), 2 parts.

Lead, Flint, or Crystal Glass. 1. Silica 336 parts; potassium carbonate, 112 parts; red lead, 224 parts; manganese oxide, $\frac{1}{2}$ part potassium nitrate, 20 parts. 2. Silica, 300 parts; chalk, 60 parts potassium carbonate, 105 parts; red lead, 160 parts; cullet, 100 parts; manganese oxide, $1\frac{1}{2}$ parts.

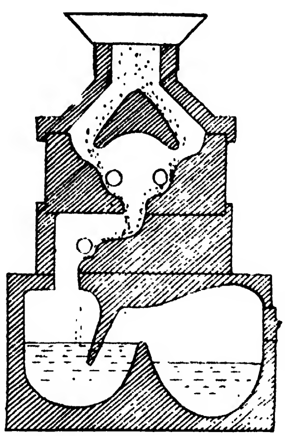
Baryta Glass. Silica, 350 parts; sodium carbonate, 100 parts; barium carbonate, 300 parts; lead oxide, 230 parts.

Lime Flint Glass. Silica, 400 parts; chalk, 35 parts; sodium carbonate, 155 parts; potassium nitrate, 20 parts; arsenic, 2 parts; manganese oxide, 2 parts.

Bottle Glass. Silica, 100 parts; chalk, 5 parts; potassium carbonate, 20 parts; sodium sulphate (Glauber's Salts), 15 parts.

Amber Bottle Glass. Silica, 100 parts; chalk, 28 parts; sodium sulphate, 40 parts; cannel coal, 14 parts; charcoal, 8 parts.

Opal Glass. Silica, 100 parts; potassium carbonate, 30 parts; red lead, 120 parts; arsenic, 4 parts; borax, 4 parts; calcium phosphate, 14 parts.



6. BECKER'S ELECTRIC FURNACE

White Enamel Glass. Silica, 240 parts; sodium nitrate, 64 parts; manganese oxide, 1 part; red lead 256 parts; arsenic, 23 parts; antimony oxide, 1 part.

Alabaster Glass. Silica, 100 parts; potassium carbonate, 40 parts; borax, 5 parts; French chalk, 5 parts.

Red Glass. Silica, 128 parts; potassium nitrate, 64 parts; manganese oxide, $\frac{1}{4}$ part; red lead 144 parts; antimony oxide, $\frac{1}{4}$ part; dissolved gold, $\frac{1}{4}$ part.

Blue Glass. Silica, 100 parts; chalk, 25 parts; potassium nitrate, 6 parts; sodium carbonate, 36 parts; red lead, 10 parts; cullet, 200 parts; cobalt oxide, $\frac{2}{5}$ part; copper oxide, 7 parts.

Green Glass. Silica, 100 parts; chalk, 20 parts; sodium carbonate, 33 parts; iron oxide, 3 parts; copper oxide, 5 parts; potassium bichromate, $1\frac{2}{3}$ parts; potassium nitrate, 5 parts.

Yellow Glass. Silica, 125 parts; potassium carbonate, 37 parts; red lead, 52 parts; potassium nitrate, 7 parts; uranium oxide, 2 parts.

Preparing and Melting the Batch. The various ingredients for the batch of glass are ground and sifted, each of the materials having been carefully weighed to ensure an uniform composition. The mixing is done either with a shovel or more often now in a special mixing machine. Formerly a calcining process called *fritting* was employed before filling the "melt" into the glass pots, but the superior purity of the ingredients now employed has rendered this operation unnecessary. The material is charged into the pots, which are already strongly heated in the furnace, and as the ingredients sink with fusion more material is introduced until the pot is full, each of the additions being allowed to melt completely before the fresh introduction of material. This first part of the process—the melting—takes from 10 to 12 hours. Gases are given off from the mass as it melts, these answering the purpose of stirring the semi-fluid mass and also helping the fusion. A potato, apple, or stick of green wood is sometimes introduced to generate additional gas during this stage. When melting is complete a scum rises to the surface, which is known as *sandiver* or *glass gall.* This scum is removed by means of a ladle. The temperature meanwhile has been increased to make the glass more fluid and facilitate the refining or *plaining.* The exact stage of refining is ascertained by taking samples of the glass and noting whether the glass is homogeneous and free from colour. When the glass is found to be quite *plain,* the temperature is reduced so as to make the glass more viscous and ready for use by the glass-blower. This is known as *cold stoking* or *standing off,* and is brought about by the introduction of a cold-air blast, so that the temperature of the furnace is continued for the benefit of other pots. The temperature is reduced gradually so that the impurities can rise to the surface.

In the case of tank furnaces only the space inside the floating fireclay rings is cleared of scum. The various temperatures are judged by the workmen, but accurate work in this direction is done by means of porcelain cones, which soften at known temperatures. The temperature of the glass furnace is variously estimated at from 1200° F. to 3600° F. The refining process takes from four to six hours.

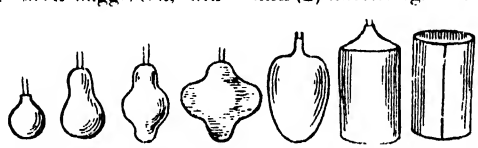
Annealing. The process of *annealing* is necessary to impart strength and durability to glass. The method simply consists of heating the glass and cooling it gradually, so as to make the glass nearly or quite homogeneous. The furnaces in which the annealing is done are called *leers* or *lehrs,* and vary in construction according to the purpose for which they are used. For sheet glass the ordinary leer consists of an arched tunnel kept heated from one end by suitable furnaces, and through which the sheets of glass to be annealed are caused to travel with an intermittent motion. For annealing small glass articles, such as tumblers and jugs, a train of trucks is caused to travel slowly along a leer, which is about 30 ft. long. The heat becomes less and less as the leer is traversed, the rate of travel being arranged so that the annealing is finished by the time the articles reach the far end.

Hardening Glass. Many attempts have been made to render glass less fragile, and so to increase its usefulness. In 1874, a French engineer, Bastie, discovered that by plunging glass vessels heated to their softening point into melted fat or heated oil, the glass was rendered so tough that a diamond would not scratch the surface. The glass so treated is, however, liable to explode or fly to pieces. Other processes, modifications of Bastie's method, have been suggested, and the Siemens method of rapid cooling between metal plates is used with some success. A modern development, the result of investigations by Schott, consists in flashing a glass of smaller coefficient of expansion upon a glass of a known coefficient, thus reducing the tension resulting from the sudden application of heat and cold. This glass is known as *compound glass* or *verbundglas.*

Crown Glass. Crown glass is the oldest kind of window glass, but is now almost replaced by sheet glass. This kind of glass is produced from melted glass by blowing it into the form of a globe, and then the globes are thrown open into flat circular plates called *tables,* by means of the operation called *flashing.* The workman takes a metal pipe 6 to 7 ft. long, and, dipping it several times into the melted glass, gathers from 16 to 20 lb. of glass upon the end. By swinging the pipe or holding it in a perpendicular position the glass is collected in a lump beyond the end of the rod. The operator then rolls the metal on an iron plate called a *marver* until it assumes a tapering cylindrical shape, the end opposite the pipe being known as the *bullion point.* He then blows through the tube to produce the shape shown in the third figure of the diagram, the glass being rotated in the meantime [7]. The glass is reheated, and an iron rod, called a *pontil* or *punty rod,* is applied to the bullion point, and the blowing tube detached by touching it with cold water at its juncture with the glass. A hole is left at the point where the blowing tube was attached, and this, by rotation and heating, is enlarged until finally, by centrifugal force, the edges flap outwards and form a perfectly flat plate of uniform thickness except in the centre where the iron rod was attached, the lump of glass being known as the *bullion* or *bull's-eye.* When cooled sufficiently the plate of glass is cut free from the punty rod by shears and then lifted by means of an iron fork into the annealing furnace. There the temperature is gradually lowered for from 24 to 48 hours, and the plates taken out and cut up for sale. Owing to the bull's-eye in the centre, squares of glass of the size of 38 by 24 in. or 35 by 25 in. only can be cut, and it is this limitation that has tended to displace crown glass by other processes by which larger sheets are obtained.

7. STAGES IN THE MANUFACTURE OF CROWN GLASS

Sheet Glass. Sheet glass is another form of window glass, and is made by blowing a cylinder and flattening out the cylinder into a sheet. A larger piece of glass can be obtained by this process than from *crown glass,* as there is no loss of glass due to the bull's-eye. The manufacture may be divided into two chief operations: (1) blowing the cylinder and (2) flattening. The workman gathers a lump of glass as in the process of making crown glass, and by rotating on the marver, reheating, swinging, and blowing, forms the cylinder, the stages being shown in 8. The end of the cylinder is opened by applying a piece of hot glass to soften the end and then blowing. The burst edges are trimmed off with a pair of shears, and the gathering rod is cracked off by applying a cold iron. The top part of the cylinder is broken off by putting a hot thread of molten glass round, and then applying a cold iron, or by first touching the part with a semicircular piece of hot iron, and following this by a drop of water, when the fracture takes the line where the heated iron was applied. The cylinder is then, while still hot, cut from end to end with a diamond cutter. The cylinder is then transferred to the flattening furnace, where it is softened by the heat, opened out flat, and passed on to the annealing chamber. An instrument called a *flattener* or *polissoir* is used for smoothing the cylinder when it has opened. The annealing process lasts three or four days. In this process a sheet of glass of the ordinary size of 50 by 36 in. is made, but larger sheets are made. The standard weights of sheet glass range from 15 oz. to 42 oz. per foot.



8. STAGES IN THE MANUFACTURE OF SHEET GLASS

When sheet glass is subsequently polished it is known as *patent plate* glass.

Continued

THE IDEAL MARRIAGE

Amateur Critics of Marriage. False Systems. The Oldest Human Institution. Its Triumph and its Supreme Importance to the World. The Family

By Dr. C. W. SALEEBY

IT has, unfortunately, become a recent fashion for novelists, writers of plays, and other men who earn their living by more or less imaginative literature, to invade the realms of sociology, to pose as authorities upon it, and to lay down propositions which the public is expected to accept. Nothing could be better than that the vital questions of society and human life should engage the attention of serious people by means of illustrations in fiction and on the stage. But grave disaster is liable to ensue when men who are unequipped for the study of sociology, whether by reading or by mental training or by temperament, permit themselves to advise the public upon matters of the most serious moment. The quack doctor of the individual body is an evil; the quack doctor of the body politic is a far worse evil.

A Pestilent Propaganda. Now, it is no less a social institution than marriage that has lately furnished material for copy to a number of contemporary writers. Thus, we have the problem play and the problem novel. It would be easy to exaggerate the harm that these do, for, after all, we do not take the theatre or even our fiction very seriously—and in this we show a rare degree of wisdom. But serious harm must ensue when men like Mr. Bernard Shaw, Mr. H. G. Wells, and even Mr. George Meredith, who have gained popularity, or even the homage of the wise, as imaginative writers, use the influence thus obtained for the purpose of propagating views upon social questions which can be described only as puerile, superficial, and pestilent. This, of course, is strong language. It is, indeed, our intention to make this protest against the wholly amateur and irresponsible contributions of these writers to the subject as strong as we can conveniently make it. In certain grave social subjects we plainly must be prepared with scientific warrant for the doctrines which serious and responsible sociologists have formulated and the truth of which they have proved.

The Only Authority is Truth. We must enter upon our study with no prepossessions in any direction. We may be on the side of established religion—and established religion is an upholder of marriage. That ground is not sufficient for our upholding of marriage. We cannot accept any social doctrine upon authority. In science there is no authority but Truth, and each man must find her for himself. On the other hand, we may be antagonistic to established religion, as are, in general, the writers who are now criticising marriage. This, however, is no adequate reason for any prejudice of ours against marriage. We must rid ourselves equally of theological and anti-theological bias. There is some excuse for both in the study of this question, according as we look at it from one side or another; but there is no adequate excuse for bias in the search for truth, and if there were it would not redeem the search from failure.

Marriage is Older than the Human Race. Our only scientific method, evidently, is the historical method. What is the origin of marriage; what are its forms in different places and different ages; what are the social phenomena with which any particular form is constantly found associated; and what, if any, are the social phenomena which the various forms of marriage actually cause?

In this country we are familiar with marriage as a civil institution and as a religious institution; it is regarded here as a civil contract, and there as a divinely ordained sacrament. Now, the first fact which we have clearly to recognise is that no Church, living or dead, is or was the inventor or originator of the institution of marriage. This institution is definitely older than any existing Church or any historical Church; i is definitely older than even the most primitive of all primitive religions; nay, more, it is older than the human race itself.

This is a fact worth noting on every ground. There is some humour in it, too, for it at once makes absurd the opposition of many persons to marriage, and exposes their ignorance. A vast deal of contemporary opposition to marriage in this country, and more especially on the Continent of Europe, is really engendered by opposition to established religion. It is thought that any blow struck at marriage is a blow struck at the Church, and it is quite definitely supposed that, practically, marriage is a product of the Church, and cannot very well exist without it.

Marriage is Not an Institution of the Church. Now, for this absurd error there is considerable excuse. It is the case that the Church, which long ago recognised the importance of marriage, took this ancient institution under its own protecting wing. It is true that the Church has sometimes taken upon itself to deny the validity and even the reality and decency of any marriage that has been made under the control of any other body than the Church itself. Here, however, we must gain a clear and final recognition of the historical fact that marriage is older than any Church, present or past. How far back, then, must we go before we come to

the origin of an institution which, however old it be, must certainly have had a beginning somehow and somewhere? We have no record, alas! of the ways and doings of man when first he made his undistinguished appearance upon the earth. The most we can do in the way of actual observation is to study the lowest types of man that are now to be found. This vastly interesting and important study is now being pursued on a comparatively large scale—and only just in time; for the contact of these rude tribes with higher civilisation—that is to say, with whisky—very soon exterminates them. However, we find that marriage is practised by man everywhere, even amongst the very lowest races that are now passing their last years on the earth.

The Beginnings of Human Progress. Now, one of the most important generalisations that have emerged from the modern study of the lowest races constitutes a denial of the old view that such races very fairly represent for our own eyes the earliest remote stages of human history. We now believe that the lowest race of which any record has been or is now being made is very far removed indeed from anything like the beginning of human progress. The most primitive of primitive races that we know has really no claims whatever to primitiveness. These races are primitive and low compared to ourselves, certainly. But the more we come to know them—their customs and traditions and languages, their gestures and their magic, and their social institutions in general—the more clearly we recognise the all but obliterated traces of a long and eventful past at which we can now only guess.

If this be so, then, we may still conceive of early stages in the history of humanity—stages earlier than any represented or hinted at by any contemporary savages—when marriage was unknown. Let us, then, outline as briefly as possible the orderly—too orderly—history of marriage which the knowledge of his time sufficed for Spencer to write. We shall not strictly adhere to Spencer's words or opinions, but shall merely state what might be supposed to be the history of marriage and what is, indeed, very commonly supposed to be its history.

Forms of Marriage. It used to be thought, then, that in the beginning there prevailed a state of what is technically called *promiscuity*. The modern term for this is "free love"—the worst debasement of two noble words with which the present writer has any acquaintance. Then, after a time, a certain amount of order would begin to display itself. There might, for instance, be, as indeed there certainly were, some more or less severe restrictions upon this freedom or promiscuity. Then, in certain societies where for some reason there was a scarcity of women, there might possibly be instituted the form of primitive matrimonial institution which is called *polyandry*—literally, the existence of many husbands. Polyandry has certainly been a fact in various parts of the world at certain times. Perhaps the commonest form it has taken is where one woman is possessed by two or more brothers in common.

Much more frequent and important is another ancient matrimonial form, known as *polygamy*, and familiar to most of us in consequence of its revival by the Mormons. It is true of polygamy, however, as of all other marriage forms except one, that it has played a very much smaller part in human life than used to be supposed. It may be said that polygamy has never been the rule anywhere. It may have been permitted, which is a very different thing. Generally speaking, among peoples where polygamy has been permitted it has been practised only by the wealthy few.

A Theory that Ignores Human Nature. In our imaginary history of marriage, then, we may suppose that, in course of time, the forms we have named, and many others, were all superseded among progressive peoples by the form which is known as *monogamy*—the union of one husband with one wife. During the historic period this is the form of marriage that has generally obtained the approval of established religion, and during the Christian era it has, of course, been the only form of legal marriage.

Now, the modern view is that this supposed imaginary history of marriage needs very considerable revision—and a revision all in one direction. It is every day being more clearly recognised by serious students that the norm, or normal type, of marriage is none other than monogamy, and that all the other forms of marital relation must be regarded as mere local and relatively unimportant deviations or aberrations from the normal type. It is, further, most positively and warrantably believed that in the course of the history of man, whether under the tropical sun or amid the Polar snows, there never was any stage of promiscuity. The writers who believed in a primitive promiscuity not only had no positive evidence in their favour, but were running right in the teeth of human nature. The key to all human institutions is human nature, and the theory of promiscuity ignored the facts of human nature—facts so deeply rooted in it that they are shared by sub-human nature—that is to say, by the lower animals. The mere mention of the word jealousy is sufficient to make anyone a sceptic so far as this theory of promiscuity is concerned.

The Triumph of the Only True Marriage. And as regards the other forms of marital relation, we find that their importance has been greatly exaggerated. The truth, indeed, is that in all times and in all places the dominant tendency has been towards monogamy, and it is monogamy that has played the great part for which the word marriage stands in the development of humanity.

We are not concerned for the moment to assert any superiority of monogamy, but merely to state the historical fact that, superior or inferior, natural or unnatural, ecclesiastical or civil in origin, monogamy has been the dominant form of sex relation in the history of mankind. It may be permitted, however, to inquire into the causes

of this general dominance of monogamy at such various times, in such various places, among such various peoples. There are certain familiar facts which might be expected to militate, and do indeed militate, against the dominance of monogamy. Of these the most important is the known character of the amatory passions in man. Thus it is undoubtedly a half-truth, but no more, that the human male is naturally a polygamous animal. Now, certainly, man, rather than woman, in virtue of his superior physical strength and endurance, has determined the form that marriage has taken ; and thus it might almost be supposed that polygamy would have become the dominant form of marriage everywhere, and certainly so wherever the number of women considerably exceeded the number of men. Now, it is true that the practice of polygamy is found to have been most extensive among purely military peoples of a low order of civilisation—as, of course, a purely military people must necessarily be. In consequence of perpetual war, the number of men in such communities is disproportionately small, and thus is established a state of affairs especially advantageous to the practice of polygamy.

The Secret of the Triumph. But the survival of any social institution is not to be explained, and is not determined, by the wills of individual men. It is determined by the needs of the race. Many forms of matrimonial or semi-matrimonial institutions may be named, besides polygamy, which offer marked attractions —some to men of one type, some to men of another type. But these institutions have played no part of any note in the history of mankind, because they did not make for the survival, but instead made for the death, of the peoples who accepted them. The writer believes that the true cause of the dominance and triumph of monogamy, as opposed to other marriage forms, is to be expressed in terms of the *children*.

The current theories of the success of monogamy will not hold water. There is, for instance, the theory that monogamy is a creation of the Church, which substituted it for pagan forms of sex relation. The valid answer to this theory is that monogamy flourished and succeeded long prior to any Church. Another theory states that the success of monogamy has been determined by Nature, which ordains that the numbers of boy babies and girl babies are approximately equal at all times and places, there thus being one member of each sex for each member of the other sex. But this theory is not valid, for, in the first place, the fact of the average numerical equality between men and women might just as well be used as an argument in favour of promiscuity; and, in the second place, man everywhere dominates his fellow-man, so that polygamy, among those who have power, is always possible. Doubtless the natural fact of numerical equality between the sexes may be admitted as a condition that is admirably consonant with the institution of monogamy ; but this fact does not begin to be an adequate explanation of the triumph of monogamy as against, for instance, promiscuity.

Marriage and Character. The theory of the present writer, to which he will return, is that monogamy has triumphed because it provides the best conditions for the children, produces the best children, who grow up to be the best men and women, and who survive in the struggle for existence as compared with their neighbours who practise polygamy—let alone polyandry or promiscuity. On superficial examination it might be thought that in the course of the struggle for existence between two neighbouring peoples, one practising polygamy and another practising monogamy, the polygamous peoples would tend to outlive their neighbours because of their presumably higher birth-rate. Now, doubtless polygamy does make for a high birth-rate, but it also makes for an infantile mortality compared with which our infantile mortality, disgraceful though it be, seems almost decent. In this instance we see illustrated the general proposition of the writer that it is in terms of the life and health and character of the children that we must express the condition which leads to the triumph of monogamy over its rivals.

The Heresy of Mr. George Meredith. The reason, therefore, why we find so scanty a record of forms of marriage other than monogamy in human history is that these forms have handicapped the races which adopted them as against the monogamous races. On the other hand, we hear much of monogamy *because it is the monogamous races that have made human history.*

Some special contemporary interest attaches to a particular form of matrimonial relation which is very expressively termed *leasehold marriage.* Its interest for us depends upon the fact that one of the greatest living men of letters, Mr. George Meredith, lately gave definite form in the pages of the "Daily Mail" (Sept. 24th, 1904) to the views which, as readers of his novels will know, he has long held. Said Mr. Meredith: "Certainly, however, one day these present conditions of marriage will be changed. Marriage will be allowed for a certain period—say, ten years." This statement of opinion naturally attracted a very great deal of attention on both sides of the Atlantic, and also on the Continent of Europe. Indeed, it has been intimately discussed all over the world during the past two years ; and it has found favour in many quarters, though it need hardly be said that no one with the smallest pretensions to be regarded as a sociologist has been found to express anything but richly deserved contempt for Mr. Meredith's opinions.

Mr. Meredith's Experiment is Condemned by History. We saw in an earlier part of our course that there is one point of view from which history may be conceived as a series of vast and varied sociological experiments, conducted by our forefathers for our benefit. We also saw that, if history be read aright, certain definite conclusions may be reached, these conclusions being strictly scientific generalisations derived by a rigid inductive process of reasoning from the experiments of history.

Here is a case in point. There is no need to try Mr. Meredith's proposed experiment, though it must lamentably be admitted that the experiment is being tried, or something very nearly equivalent to it, under the conditions in the United States which permit of divorce at the pleasure of the contracting parties. But apart from this contemporary and disgraceful experiment, which is alarming the most thoughtful and least prejudiced of observers, we can fall back upon the experiments of ages long past; we can point to the condition of tribes which in modern times practise leasehold marriage —degraded, degenerate, worthless, and rapidly disappearing. But it is not even necessary to condemn leasehold marriage by pointing to facts of observation and experiment. The *a priori* method of reasoning is quite adequate alone to serve for its utter condemnation. The sociologist has a criterion by which he is enabled to judge of marriage methods. What, he asks, will be the consequences for the coming race?

Marriage and Society. The fundamental character of the sociological point of view is that it looks ahead. To the sociologist the individual is nothing as an individual, though we must discuss this from another point of view in a subsequent chapter; he is concerned with the life of society, which outlives many generations of individuals. This it is which endows marriage with its supreme importance for him. He leaves it to the psychologist to inquire as to the comparative worth of marriage and other forms of sex relation to the individual; but *he* must inquire as to its influence upon the future life of the society in which it occurs. Marriage vindicates itself in his eyes because it furnishes the one perfect condition for the young generation whose business it is to continue the life of society.

Thus the sociologist looks with entirely distinct interests upon the two kinds of marriages. The childless marriage is doubtless of interest to the psychologist—the student of character; but it matters scarcely anything at all to the sociologist, for it signifies nothing for the future. True, it is a social relation, but, so far as he is concerned, it amounts to nothing more than that two persons, who happen to be of opposite sexes, live in the same house and arrange their finances jointly. It is the appearance of a baby that vitally interests the sociologist, for now he has to consider not merely a marriage, but a marriage leading to the *family*. In this respect he is like Nature. She, also, is "careless of the single life," and for those who are not parents, whether they be married or unmarried, she cares little or nothing. "Her supreme interest," as the present writer has said elsewhere, "is with those chosen individuals upon whose characters and behaviour, as upon no other factor in the universe, the whole future of the race depends."

The True Test of Marriage is the Family. The fertile marriage is of supreme importance to the sociologist because it leads to the establishment of the family. The type of the family, historically considered, has varied in dependence upon the type of marriage, and we may lay down the proposition, as sociologists, that the value of any form of marriage may be judged by the quality of the type of family which it tends to produce. It is this fact, in the present writer's opinion, which explains the observed preponderance of monogamy in the history of man. Monogamy produces the best type of family; the best type of family produces the best type of society; and thus the races which have used other forms of sex relation in preference to monogamy have played no part of moment in history, and have left scarcely any records at all behind them.

As the arrangement of this and the allied courses indicates, we are attempting to base sociology upon "the solid ground of Nature." We can have no more certain warrant for any social institution than that we find it sanctioned by the facts of biology. Now, it is an extremely noteworthy fact that the biological sanctions for marriage are actually older than the human race itself. In many of the lower animals we find that institution called the family—a family produced by a monogamic union of less or greater permanence. This fact of *animal marriage* is of the utmost interest to the sociologist, who builds upon biology. It furnishes him with yet another of the many instances where institutions supposed to have been invented by man, by the law, or by the Church, are found to have played their part in the evolution of life even before the emergence of man.

The Ideal Family. The ideal family is that produced by monogamy. Not very far behind it, perhaps, is the type of family produced by a qualified polygamy, such, for instance, as we observe in the patriarchs of the Bible. Relatively to these, and especially to the former, all other kinds of marriage stand condemned; and this constitutes the ultimate warrant for monogamy. Contemporary practice and experience may be quoted in proof of the assertion that the monogamic family constitutes the best condition of environment for the rising generation. The best kinds of family of this type constitute the realisation of the ideal. We are incapable of conceiving anything better. Those who advocate "leasehold marriage, with State care of the children," or those who advocate the "nationalisation of the children," as a general principle, may be counselled to consider the experience of those whose duty it is to make provision for pauper orphans or other children who are necessarily thrown upon the State even under present arrangements. Many different plans have been tried for dealing with such children. These range from the most unnatural to the most natural. The first description surely applies to the herding together in large institutions of children all of one sex, and, as far as possible, all of one age. This plan is as remote as possible from Nature's indications, having nothing but (false) economy to recommend it. At the other extreme is the boarding out of these children under conditions as nearly as possible approaching those of the normal family.

The Supreme Value of True Marriage to the Race. In general it may be said that "the nearer our provision goes towards the establishment for those children of conditions simulating those of the family, the better are the results. . . . . Indeed, what sane person will dispute that the best prospect for an orphan is afforded when it is adopted by some parental-hearted pair who will treat it as if it were one of their own children ?" No one who has paid the smallest attention to these facts can hesitate to admit that the proposals for leasehold marriage and nationalisation of the children touch the ultimate bottom for ignorance and short-sighted stupidity. The more we study the family, and substitutes for the family, the more clearly we see that the institution of monogamic marriage has the final warrant of Nature. Monogamy has survived, not because of the injunctions of any Church, but because it has supreme "survival value." This it has "partly because it implies a due control of male passion and a due limitation of female endurance; partly because it promotes the development of the higher sentiments and represses the lower; *but pre-eminently because it provides for the coming race a peerless environment.*"

Why Other Systems Fail. Communal, or collective marriage, group marriage, leasehold marriage, and "pooling the children," have all been the subjects of experiment by man in the past. They have all failed, and all for the same reason, because they did not work. "They had no survival value, and the societies which adopted them are no more. They had no survival value because they prevented the formation of the family, upon which alone must be founded any human society that is to endure."

Now, it is true that oaks survive and multiply, and flourish without the aid of the family. It is true also that there are some sub-human societies, such as those of the social insects, which flourish without any institution that really corresponds to our family. It is true also that among birds the family lasts for only a short period, and birds still flourish, even though monogamy, as practised by them, may be an extremely brief affair. If leasehold marriage, so to speak, be an efficient social institution among birds, why not also amongst men ?

The Key Fact of Marriage. The answer is that there is a fundamental difference between the early stages of the life-history of man and those of the life-history of any other animal, not to say plant. If the young acorn falls upon good soil, it is quite independent of any care on the part of the oak which bore it. The young insect may need much care for a short period, but very soon it is able to find its own living. The young bird must be fed at first by its parents, but only a short time need elapse before it is able to fly away, and depend for life upon its own activities. But the young of the human species are different; they pass through an extremely prolonged stage of dependence in youth. Not only is this longer than in the case of any lower animal, but the degree of dependence is much greater. It is perhaps the most remarkable paradox in the whole of living nature that of all young beings the young of the dominant animal, the "lord of creation," should be the most helpless, and the longest helpless. This fact undoubtedly has a great meaning, even a greater than the meaning on account of which we have here referred to it, which is that the family and the due exercise of parentage, more or less important in most of the lower animals, are of supreme importance for man. So long as man retains this character—that at birth he is utterly helpless, and that for many years afterwards he is incapable of fighting his own battles—so long will the survival value of marriage be supreme, and so long will the empire of the earth be given to those societies which avail themselves of that value.

Marriage will Survive all Criticism. We may speak indignantly of amateur critics of marriage at the present day, and our indignation is warranted, but if we were able to take a quite impartial view, caring nothing for any one society rather than another, we should have no need to concern ourselves. No institution that makes for life is really in danger or in need of our assistance. There is a natural automatic process which has been at work since the beginning, and which will continue working to the end: it is the process which Darwin called "natural selection," and Spencer "the survival of the fittest," and it ensures that whatever individual character or social institution makes for life will survive. Marriage, as we have demonstrated, is such an institution, and it will be practised upon the earth a hundred thousand years hence. Here and there a society may try something else, forgetful of the fact that it is not worth while to repeat any of the old experiments which have already been made; but the society which abandons marriage will simply go under before the society which does not. Thus fell the "glory that was Rome," and the same cause—a decline in this fundamental morality—would assuredly tend to the destruction of an empire greater still. It is at the heart that empires rot.

The two chief works upon marriage in the English language are—excepting, of course, that part of Herbert Spencer's "Principle of Sociology," which deals with the subject—Professor Westermarck's "History of Human Marriage," carrying the investigation onwards from the stage where Spencer left it; and, secondly, the "History of Matrimonial Institutions," by Professor G. E. Howard, of the University of Chicago (Fisher Unwin 1904).

Continued

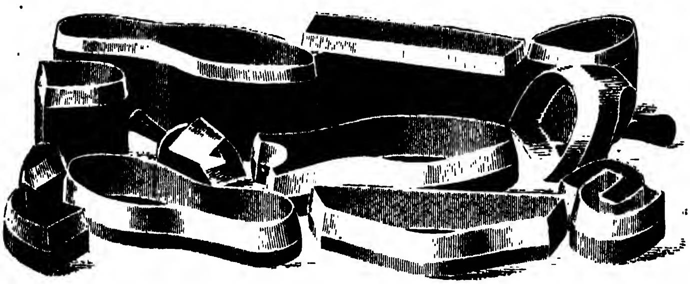
Group 20
LEATHER
13
BOOTS AND SHOES
continued from page 4437

BOTTOMING & HEELING BOOTS

Cutting Dies and their Use. Lasting, Attaching Soles, Cementing, Channelling, Stitching, Heeling, and Finishing

By W. S. MURPHY

Cutting the Stuff. Cutting bottom stuff for the boot factory is a trade by itself, at which a man may find useful employment for both head and hands. When the leather comes from the stores into this department, the hides are ranged, trimmed, and rolled. No doubt, the man who puts the butts and side pieces together thought he had done his work pretty thoroughly, and so far as leather classing goes, he may have done the best possible; but we have something more to ask from the leather. The cutters need pieces of such shape and size as they can put them into the machines in batches. All the leather to be cut has, therefore, to be sorted. Sorting is not merely a case of putting hides of the same size together, or getting them trimmed or shaved to requisite dimensions. Before starting on that job you had better make yourself well acquainted with the various tannages and classes of leathers. Verbal directions in this matter are useless. That is to say, you have to learn the trade by practical experience, step by step. Having put the hides of each class together, we range them on the cutting machines, which may be either guillotine or horizontal, according to the class of leather with which we are dealing.



50. KNIVES FOR CUTTING BOTTOM STUFF (B. U. Shoe Machine Co., Leicester)

Rolling. When the hides and pieces come from the ranger, they are square-sided. But we do not hand them over to the cutters yet. Leather, as it comes from the tanner, is not of the close fibre we need for boot-making. To stiffen and close it, we pass the leather, after wetting, through a pair of heavy rollers. From the pressure of the rolls the stuff comes out clear and firm.

Cutting Soles. The different kinds of leather are now distributed among the various cutters. Light flank pieces go to the cutters of stiffenings, shoulders to the insole cutters, butts of graded sorts to the sole cutters, and scraps of heavy leathers to the heel lift makers. Now we see the benefit of the ranging. For every size of boot we have a special set of cutting dies [50] and presses ranging in size and power from the foot-driven press that cuts lifts or side pieces to the heavier presses that stamp out the strongest soles. Revolution presses do not demand that the leather be ranged; but it can be cut up in whole sides or butts [51]. If we are to get the best results from these mechanical cutters, the leather must be of such uniformity as will enable us to go ahead without stopping to adjust and alter to suit variations in size and grade of leather. The edge of each knife blade is exactly the shape of the piece of leather to be made. Look along the edges of a sole knife, and you see that the shape is a sole, and so with all the others. Fix the leather under the press, lay on the knife, and put the driving belt into action. In a moment there is a crunch, and the soles are cut.

In principle all the die-cutting machines are the same; after having learned to work one, it is easy to take up the others. One thing must be constantly borne in mind—those machines need the assistance of the operator; they are not automatic, and to work them a man must give his whole attention to what he is doing. A leather-cutter is a skilled workman, though not always rewarded as such.

Insoles and Welts. An insole comes from the cutting-room a plain piece of leather shaped to the sole of the last; but it could hardly be sewn in that form, even by hand. The edge of the insole which lies under the top is pared away, leaving a corner into which the sewing holds: this is technically called the *lip*. Forming a lip is a delicate operation; but our mechanics have got over it. One of the best is the "Goodyear" channelling machine, the cutting parts of which are a slanting circular blade working on a flat disc. Lay the insole on the disc, and the knife cuts round, forming a clean lip in a very short time.

Cutting Welts. Welts in the factory are long continuous strips of split leather. The short strips of leather have been cut from the hides, and now we run them through the welt-splitter, which levels them neatly with wedge-shaped sides. The ends of the parts are neatly spliced and joined with cement to form a continuous ribbon of the length required for the machines. They are also cut with an ingenious tool called a *welt-stripper* from shoulders dressed specially for the purpose.

Lasting. Our materials are now shaped, and we assemble them, to begin making up

The uppers, the lasts, the insoles, are here, and now begins that arduous and difficult operation, the lasting. Up till the end of the nineteenth century, hand lasting [53] was carried on in the best equipped factories; it made a gap in the mechanical organisation of the factory; the hand laster could paralyse the greatest factory in the world.

Machine Lasting. Between about 1898 and 1903 no fewer than six efficient machines were placed on the market, and improvements have been constantly going on since. The method of the best of these machines [52] is an imitation of the hand lasting action. Last and insole are inserted into the upper, so as to hold easy, and then put into the mechanical laster. Presented to the machine in a slanting position, with the insole uppermost, so that we can see exactly what is being done, the top is gripped by a pair of power-worked pincers that pull it upwards, drawing it tightly on to the last. The pincers are adjustable, so as to work upon any size of upper. Wipers now come into operation and lay the upper close to the insole, and five tacks are driven in simultaneously to make the work secure. This operation of *pulling-over*, as we name it, is begun and completed in fifteen seconds.

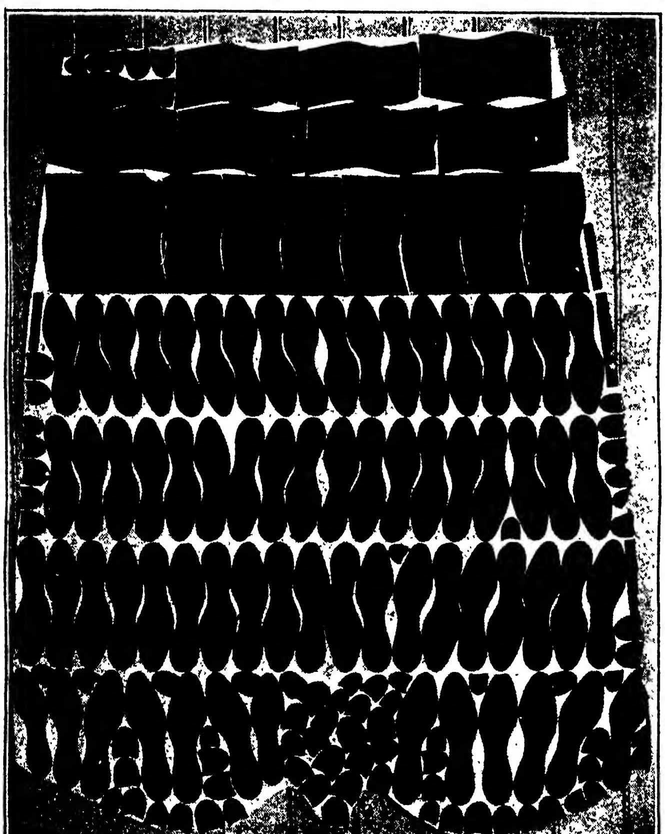
Series of Lasters. Among the other lasting machines there is a series with which the worker should be acquainted, the set grading in degrees of complexity. Taking the common laster first, we find it to be a rather complex mechanism, though not difficult to work, the parts being strong and automatic. Our second machine [52] has a twist motion that brings the top on all sides close up to the feather of the insole, and a slanted tack-driving arrangement that drives in the tack and fastens the upper.

Joining Insole, Welt, and Top. We are ready to begin what has been described as the "impossible" mechanical operations of the boot factory. Handicraft bootmakers used to ask, How was it possible for a machine to put a thread through welt, upper, and insole all at once?—convinced that it could not be done. But the machinists of the boot factory offer us a choice of machines for the purpose, each one advertised as capable of doing perfect work. One thing helps another, as Arkwright is reported to have said when he organised the cotton factory. The mechanical lasters are designed to make the work of the sewing machines easy. The springs and levers of even the least complex of these machines are so numerous as to render description unintelligible even to the worker. Yet the action is perfectly harmonious. Set the boot in place, and see how the work goes on. Through welt and upper and insole the stitches are made by the cunningly-devised mechanism, [54], and as each stitch is made the boot moves forward the length of the stitch [27].

On this machine is a ball of white thread, and at the side is a coil of welt. When the boot is placed on the flange under the needle, the thread comes through a bath of wax kept constantly at melting point by the steam heater, and at the same time the welt uncoils to the boot. Both are manipulated by the needle, which draws the thread through welt, insole, and upper, and firmly binds them together.

Preparing for the Outsole. As we have taken it from the welt-sewing machine, the boot would hardly make a good foundation for the outsole. The seams are rough, and between the surrounding welt and the insole there is a hollow space.

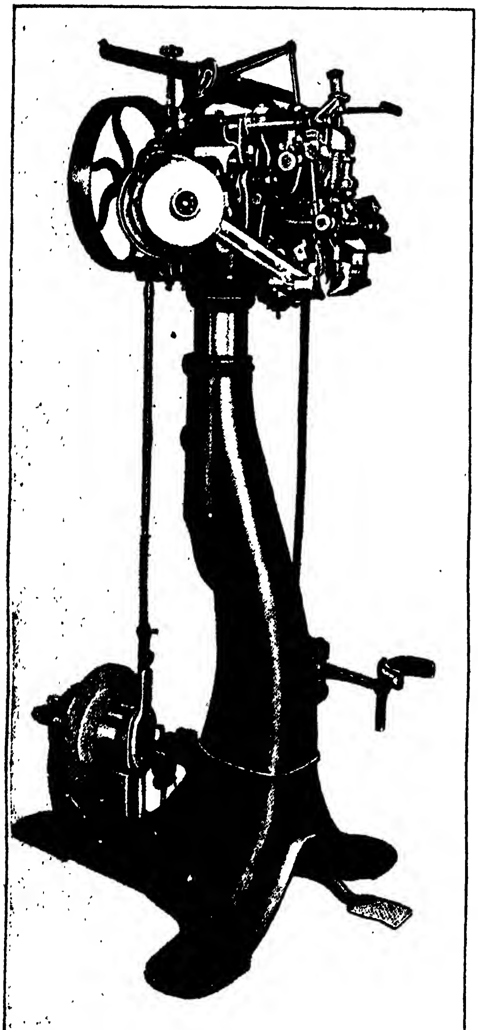
Filling. Very light boots are packed with felt soles thinly covered with cement; but for strong boots the packing is scraps of fine leather, graded to the thickness of the



51. SOLE LEATHER CUTTING
showing how a hide is cut up with little waste

welt. For this purpose we have a small shaving machine, in which a boy puts bits of leather, and brings them out neat packing pieces. At his side is a small self-heating vessel full of melted rubber solution, and with the brush attached he sticks the insoles and puts in the pieces of packing.

Levelling. When the solution is dry, we take the boots to the inseam leveller, which trims the welt and lays the seams at the same time. Like the rest of our machines, the seam trimmer is very complex in the mechanism and very simple in operation. All we need to do is to hold the boot in the jaw of the machine and let it throb round the seams, smoothing each stitch down as it goes along.



52. CONSOLIDATED HAND-METHOD LASTING MACHINE (B. U. Shoe Machine Co., Leicester)

Soling. The boot soles are passed on to the blocking press. Pair by pair the pieces of hard leather are fed in on the top of the foot-moulding blocks, and over them comes down the matrix, to lift again, and let out a pair of finely-modelled soles.

Cementing. Sole-laying is our next important work; but before that can be done we have a choice to make. The question now is whether the soles are to be pegged on for sewing or cemented. The best and most satisfactory is the cementing, and for this we have a fine machine. Within a jacketed pan, heated according to the general system of the factory, rubber solution is kept soft, and within the pan revolves a round brush. Over this brush the soles are fed, and it smears the flesh or inner side with the solution.

Sole-laying. We have to be smart now, for the rubber cement dries quickly. At the side is the turret sole layer. There are several, but we can work only one. Fixed on a revolving platform, this little tower of mechanism holds six iron soles lined with pads of soft rubber, and on the platform under each movable holders that let in the lasted boots and hold them tight. With one hand take the clasping levers, and with the other set in the boot with the sole on it. Now fix the grips on toe and last, and the top pads of rubber come down to make the whole fast in a firm grip. The turret moves round, and offers another station for your boot; you repeat the operation. When the six stations have been filled, the boot first fixed comes round ready to be taken off, and its place is filled with another boot. You can lay a thousand soles per day with this machine. There are other sole-laying machines equally serviceable. Another interesting model has a vertically revolving motion, with four stations. As the machine slowly goes round, the station at the top automatically relaxes, the action of turning clamping the laying press down on the newly inserted boot. The variety of sole-laying machines is considerable, and the effort of machinists is to render them as gentle and firm and automatic as possible. The maximum capacity, so far as we have seen, of the best of these machines is about 1,200 per day of actual working.

Sole Rounding and Channelling. Sewn soles are channelled to hide and protect the stitching. Channellers are called upon to work any variety of machines. Some are merely little knives held in the grip of a motor, with a stand for the boot; others are more complex and aim at rounding the sole while making the channel; but none is difficult to understand. The chief thing to watch in these machines is the adjustment. A thin sole will not stand the depth of channel that a heavy sole requires.

Stitching. The soles are now stitched to the welt by a machine which is called the "rapid stitcher" [55], the boot being laid to the machine without removing from the last.

Blake Sewers. Boots are often made without a welt by sewing with a "Blake," already described. This machine is still in general use. No boot factory sewer can afford to be in ignorance of the working of this machine. On the head of a tall standard the complicated mechanism is set, while from the platform in front

OPERATIONS IN BOOTMAKING

53. Lasting by hand 54. Sewing in a welt on the Goodyear welting machine 55. Working the Goodyear rapid stitcher 56. Bottoming, or levelling the sole to shape of the last 57. Attaching the heel by heeling machine 58. Trimming the sole edge by machine

protrudes a horn. Over this horn the sewer puts the boot, and needle and thread make stitch after stitch, piercing through sole and insole, making a fine seam in a channel cut in the sole by a sole-channelling machine as though it were only thin cloth that was being sewn.

Pegging. The sewn boot is still the favourite; but, curiously enough, the first machine-made boots were pegged in the soles. It may be admitted that the early bootmakers by machinery did not understand the British climate, and introduced a kind of pegging suited only to a dry and equable climate, or a population that never walked in the wet without indiarubber overshoes. By pegging we mean that the soles are secured to the uppers by small pegs. Stitches may seem to grip firmer, but threads cannot last as long as wood or brass. Nothing daunted by their first failure, the inventors of the pegging machines have worked away, and now have produced many contrivances which make really good work. We hardly think the pegged sole will ever displace the sewn one in this country; but a trade of some dimensions has sprung up. The idea which revolutionised the pegged trade was the substitution of a screw rivet for the ordinary peg. The pegging machine most familiar to us resembles in general appearance a kind of "Blake" sewing machine. On the horn in front the boot is set, but instead of the needle a screwing punch containing a screw-tapped wire comes down and drives the peg through welt and sole, automatically cutting off and riveting what is practically a wood nail in the boot. Swift and effective, the action is repeated automatically. Spacing between the pegs is done by the machine, and the intervals may be made as small or as wide as the operator desires.

59. FOREPART CUTTERS

Heeling. Hand-working bootmakers build the heel on the boot, lift by lift; but in the factory the heel-builder is a specialist. The wide variety of heels we are called upon to make has rendered this inevitable. Square heels, round heels, peg-top heels, low and high, broad and narrow, the variations run through the whole range of sizes and classes. If any speed were to be attained in this department, some method of simplification was bound to come. The end was gained by making the heels first, and then fastening them to the boot. We admit that these heels have not the spring of the hand-built heels; but the difference is small and cannot be helped. For the highest class of boots we make split lifts, and produce a heel equal in every respect to the best hand-made; the consumer, therefore, has it in his own hands—he can get the article if he will pay the price.

Building the Heel. The bottom course, or foundation of the heel, is called the *seat*. This is made level with the sole and usually comes off the same hide. Next is the bottom lift, also solid. The two lifts above may be split with inside packing, in the approved hand-made way. The lifts are cemented together by a solution of rubber or other paste, and built on ingenious machines, the most common models of which resemble miniature hydraulic presses in construction and principle.

Putting on the Heel. Heels are attached to boots by various machines [57], the greater number by merely riveting presses, which clench the wire nails left protruding from the heel-seat into the sole and insole. A machine much favoured by manufacturers of heavy boots works on a peculiar plan. Into a disc the nails are fed head downwards; heel and boot are placed together in position; the press comes down and the hammer comes up, driving the nails into the boot and heel. The top pieces of the heel are nailed by a special machine [61] that drives the "nails" regularly and at a very rapid rate.

Sole-levelling. When we get the boot from the making-up department, the channelling of the sewn seams gapes and the sole may not lie quite flat. Obviously, if you can pass a roller firmly enough, and yet yielding to the proper shape of the boot, over the sole, it will be levelled. On this idea the best levelling machines [56] are constructed. The rollers are hung on spring attachments; alternatively, the stand of the boot is spring-seated, and the rollers move firmly over the soles.

60. "SMITH" HEEL-TRIMMING MACHINE
(B. U. Shoe Machine Co., Leicester)

Finishing the Boot. Heeled and soled, the boot has been built together; but it must not yet pass out of our hands, for it is a rough production. Most factories do not class the departments as we do; they make some of those workers whom we consider finishers work in the soling and heeling departments. This matters little; but a more rigid method of division, such

as we propose, would help all parties. When the sole-sewers and heel-fixers have put the boot together, the work of that department of the factory is done. The rest belongs to the finishers. It seems ridiculous that sole-levelling should be included in soling while edge-trimming belongs to the finishing division.

Heel-trimming. Though finely cut to shape when laid on the boot, the heel has margins which can be dispensed with only after it has been seated on the boot [60]. The front, or breast, of the heel has been left rough for shaping to the level of the shank. Breasting is very hard work, and needs a sharp, strong knife. Over a dozen kinds of breasting machines are regularly employed, but the best are very simple. A knife the shape of the breast required is fixed on the head of a press; the boot is set in the stand, and the knife shears down, cutting a clean breast.

To give our heel a solid appearance, we take it to the scouring machine, and on flat sand-paper, running on spindles, the heel is smoothed to a fine level.

Edge-trimming. Like the heel, the sole has been left with rough edges, and for trimming these we have the machine cutters. Here the special character of bootmaking machinery comes out strongly. The edge-trimming machines are nothing more than mechanically-driven knives [59], shaped to suit. Instead of the flat blades we use by hand, the cutters are grooved blocks of steel, cast in a wheel and fixed on a spindle. Against the revolving cutters the boot is held [58], and a fine edge is the result.

Buffing. In most trades, buffing implies polishing; but with us the meaning is the opposite. The object of buffing is to take off the old surface of the leather of sole and heel, and prepare it for receiving a new surface. But we use buffing wheels, like other workers, the difference being that, while wood and steel are smoothed by the rough surface, the leather is made rough. On the rims of the wheels bands of coarse emery are fixed. By applying the sole and heel to the running wheel [62], we scour off the surface of the leather in a regular manner. One thing has to be specially watched, and that is the work of the emery on the sides of the soles, or the edges so carefully cut will be ground down. Simple as it looks, buffing can not be learned in a moment. Nothing can obliterate the streaking and scudding of defective buffing. Dust flies from the buffing wheel at a great rate. To keep the air of the workshop clean and preserve the health of the operator, the wheels are hooded over with covers, through which attached fans suck the leather dust into closed receptacles.

62. BUFFING, OR SANDPAPERING

61. NAILING ON THE TOP PIECE

Sandpapering. Similar in construction, the sandpapering machines begin to build smoothness on the rough work of the emery buffing wheels. The rollers are made to resemble in feel and elasticity the human fingers, being composed of felted material under the sandpaper.

Blacking, Edge-setting, and Polishing. In this division the skill of the workman counts for more than the speed and structure of the machines. So long as the present fashion of boots maintains its hold on the popular taste, no other system, it seems to us, is possible. The routine of the hand-working bootmaker is preserved. First,

the hot irons are run over the edges of the sole [63], the back of the heel, and the skiving of the waist or shank; next, the blacking or ink is brushed on; next, the heated setting irons run round and over, making the dark places shine like mirrors; and then, with grease and blacking, brushes and cloths, the whole boot is made beautiful.

We work with machine tools in the factory; that is the sole difference between the ancient and the modern practice. Where the bootmaker heats his irons at a gas jet, we have the gas stove, or patent ring; we fix the irons in a machine and hold up the work, instead of grasping the handle of the irons in our hands and leaning down to give pressure on the polisher. For the little ink-brush we have the patent circular brush, and for the cleaning cloth a pneumatic felt pad. One great and important difference remains, and it explains why machinery has been adopted for hand labour in this, the delicate touching-up of our work. In ten minutes, without stress, we can turn out as much work as a bootmaker, working hard, could do in two hours.

64. TREEING THE BOOT

Tying. When finished, the boots pass in pairs on to the tying machine, which, with one stitch in each, links them together. Then they pass into the treeing department [64]. By the treeing device we have been enabled to dispense with the last during the finishing processes. Formed of several pieces, the tree goes into the boot, and is screwed up to the size of the last, shaping the boot again, and fixing it in the proper form.

62. SETTING THE EDGE

The boot has been made ready for the wearer; who that may be cannot be guessed, but we have done our best to give a good boot.

Technical Trade Teaching. With all its limitations, the bootmaking machine factory produces good work, and handicraft can never again obtain a strong hold on the boot market. It is satisfactory, therefore, to find our technical schools in London, Leicester, Leeds and Glasgow teaching machine bootmaking instead of confining their efforts to imparting a craft which has sunk into a subsidiary though artistic branch of the industry. Handicraft bootmaking is the foundation of the trade, and, as such, should be taught, but knowledge of machinery is indispensable to the workman of the present day.

Many of the photographic illustrations in these articles were taken in the factories of the Trueform Boot Company of Northampton and London.

BOOTS AND SHOES *concluded*; *followed by* SADDLERY AND HARNESS MAKING

SEWAGE DISPOSAL

Sewage Outfalls. River Pollution and Purification. Utilisation of Sewage. Different Systems of Treatment

Continued from page 4463

By Professor HENRY ROBINSON

WE now consider the question of the disposal of the sewage from a town. This must be effected without causing a nuisance by polluting the air, the water of a river, or the sea.

If the town be situated near the sea or a tidal river, there is a natural tendency to assume that the sewage can be got rid of by discharging it there. Before this can be safely done, it is essential to take careful float observations [see page 1016], to ascertain whether, under every condition of tide, the sewage will be carried away without causing a nuisance by polluting the foreshore, either near the outfall or elsewhere.

In determining what standard of effluent should be required at any sewage outfall, each case must be considered with reference to its own special conditions. To insist on a *perfectly* pure effluent would, in most cases, be unreasonable. In past years it was unattainable, but is now possible, as was the case at Maidenhead, by *electrozone*, a sterilising fluid produced by passing a current of electricity through saline solutions.

Management of Outfalls. Another matter deserves mention, and that is in reference to the management of sewage outfalls. Even supposing the most suitable system has been carried out, the anticipated results may not be attained owing to the want of care or intelligence in managing the outfall.

In some places where it has been found necessary to discharge the sewage only at certain tides, to ensure fluid filth being carried away at ebb tides and not returned at the following flood tides, storage chambers have been made at the outfall to retain the sewage until the proper time for its discharge has arrived, when, by raising a sluice, either by hand or automatically, the stored sewage is let out from the chamber. This arrangement is liable to failure in the event of heavy rainfall following a period of dry weather, when the sewers are flushed and the quantity arriving at the outfall is more than can be retained there until the right time for its discharge into the sea or estuary. In cases where such an outfall sewer receives storm water the storage chamber may be a very costly work. An alternative method of dealing with this temporary excess is to lift it by centrifugal pumps the few feet necessary to discharge it above the top of the tide when there is a coincidence of a high tide and a heavy rainfall. Such an arrangement, however, requires to be worked almost automatically, as the coincidence may happen only once a year, and then in the middle of the night. Anyone desiring to follow this matter further can study two recent cases of pollution which were decided in the Courts. One is " Lord Gifford *v.* Chichester Corporation," where the action was based on the pollution of the air and foreshore in an estuary. The other is " Foster *v.* the Warblington Urban District Council," where the plaintiff's oyster-beds were polluted by the discharge of sewage near them and his oyster trade interfered with. Both the cases were decided against the authorities responsible for the sewage outfalls, and they will serve as a precedent for future reference.

River Pollution. The Rivers Pollution Prevention Act, 1876, was passed to meet the well-founded demand for such legislation as would prevent the injury and pollution of rivers by the discharge into them of refuse, putrid solid matter, or other waste or noxious or polluting liquid or solid sewage matter. The Act deals with the evils under three heads: (1) solid matters; (2) sewage pollution; (3) manufacturing and mining pollution. The prohibition as to putting solid matters into rivers is absolute. The prohibition as to the discharge of sewage or poisonous noxious polluting liquids from manufactories or mines into rivers is accompanied by the proviso that no offence shall be deemed to have been committed where the fluid is conveyed by a channel used, constructed, or in process of construction at the passing of the Act, if the best practicable and available (or reasonably available) means has been used to render harmless the sewage matter or polluting liquids. In 1893 the following important amendment was enacted in explanation of Section 3 of the Act:

> "Where any sewage matter falls or flows or is carried into any stream after passing through or along a channel which is vested in a sanitary authority, the sanitary authority shall, for the purposes of Section 3 of the Rivers Pollution Prevention Act, 1876, be deemed knowingly to permit the sewage matter so to fall, flow, or be carried."

The result of legislation to protect our rivers is not very satisfactory.

Self-purification of Rivers. While referring to the avoidance of river pollution by discharging foul matters into it, we may mention that there may be cases where slight pollution may be tolerated owing to the amount of matter discharged and the point where it reaches the river, together with the relation between the volumes of both, preventing appreciable injury. It was once thought that "a river once polluted remained always polluted." Those who have to advise about sewage disposal recognise that a river can be self-cleansing within certain limits. The number of minute organisms and plants which are found in a river are instrumental in destroying organic impurities and afford under the microscope a means of determining the character of the water. These organisms are found to multiply and thrive in a sewage-polluted stream to an extent enormously greater than they would in the same

stream if unpolluted, although they exist in fresh water. They may be said to act as scavengers; but, if the amount of impurity be too great, the organisms are, it is thought, less able to exert this beneficial action. Minute plants also help, by giving off oxygen when exposed to the light, and thus assist to oxygenate the water.

Liquid Refuse from Manufactories. The admission of liquid manufacturing refuse into sewers has often increased the difficulties attending the treatment of sewage at outfalls, but it is to be anticipated that these facilities will be very much curtailed. The local authority may refuse to allow trade effluents to enter sewers on any of the following grounds: (1) that they would injure the sewer; (2) that they would prejudicially affect the disposal of the sewage; (3) that their volume is too great for the capacity of the sewers; and (4) that their admission to the sewer would interfere with some order of a Court of competent jurisdiction.

The admission of trade wastes to sewers in large quantities causes difficulty in treating the sewage at the outfall, especially when the waste is not admitted at regular intervals coinciding with the varying volumes of sewage, and when undesirable solids are not removed. If the conditions as to the admission of the waste be observed, there is no trouble in dealing with it, when it is associated with sewage in reasonable quantities, as the sewage sets up the necessary putrefactive change if the waste is either acid or alkaline, unless in excess, when it should be neutralised before admission to the sewer. The Sewage Commission are of opinion "that the law should be altered so as to make it the duty of the local authority to provide such sewers as are necessary to carry trade effluents as well as domestic sewage, and that the manufacturer should be given the right, subject to the observance of certain safeguards, to discharge trade effluents into the sewers of the local authority, 'if he wishes to do so.'"

Tidal Waters. The requirements of the Public Health Act with reference to the purification of foul fluids before their discharge into rivers, etc., has not been considered as applying to tidal waters, and the Rivers Pollution Act has only very rarely been put into force. Inasmuch as it is illegal under the common law to pollute the air, or the rainfall after it reaches the earth, it is equally illegal to cause a nuisance by polluting the tidal water of an estuary, or the foreshores adjoining, as the Courts have held in the cases to which we have referred.

Compulsory Provisions. The further powers now conferred on county councils, joint committees, and river boards will lead to a closer scrutiny of rivers and streams, and to the detection and abatement of pollutions.

In arranging sewage disposal works it must be borne in mind that the Local Government Board at the present time require provision to be made for dealing with the dry weather flow, and a further five volumes, or six volumes altogether. If the town be drained on the *combined system,* three volumes must be treated as sewage proper, and the further three volumes has to be disposed of on specially-prepared filters or on land. If the town be drained on the *separate system,* two volumes must be treated as sewage proper, and the further four volumes has to be disposed of on filters or land.

Quality of Sewage. The quantity of sewage delivered to an outfall has been regarded too much as the governing factor, without reference to the quality. The facts which are now available with respect to the results of treating sewage by bacterial action will no doubt be productive of elasticity in the Local Government Board's requirements, and will entail a more intelligent consideration, based upon detailed expert information of the condition of the sewage of the town in question. At present too little attention has been devoted to this, resulting in the enforcement or adoption of unnecessarily costly works at sewage outfalls. After the sewage arrives at the outfall it is passed through a chamber in which is arrested floating substances such as corks, paper, and the like, which must not be allowed to pass to disposal works of any kind.

Irrigation. If suitable land be available near a town, and the sewage can be conveyed to it without any engineering difficulties, its utilisation for agricultural purposes is possible.

Sewage farming has too frequently been regarded only from an agricultural point of view, whereas it must be treated as a combination of both sanitary and agricultural interests. These two, however, can be successfully combined only where a sufficient area of suitable land is acquired to enable the crops cultivated on it to receive the sewage only when they want it, at the same time that the sewage is purified on other areas when it is not wanted by crops. When this cannot be accomplished, the agricultural part of the matter must be disregarded, and the filtration and purification of the sewage as a sanitary necessity should be alone kept in view.

It is now clearly established that the changes that have to take place in sewage to effect purification, or that are necessary to enable the manurial ingredients in it to be best adapted to the requirements of plant life, are due to the nitrifying action of micro-organisms. Where the land under treatment is open and pervious, the most solid part of sewage, as well as the dissolved and finely suspended organic matters, admit of being liquefied in the interstices of the soil, and of being converted into the harmless nitrates and nitrites which are so beneficial to plant life. Where the land is impervious this can be only partially effected, and in such cases the liquefaction of the solids by bacteriological influences has to be brought about by methods that are described elsewhere, so that the fluid that is applied to the land is both free from what would clog the pores, and is at the same time highly charged with the nitrates and nitrites which are available for vegetation. If they are not required by the crops they are in a form that can pass away without causing pollution or nuisance.

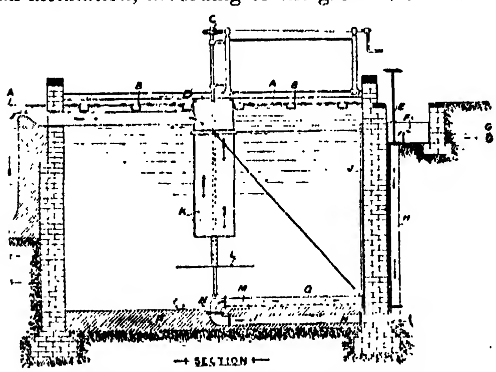
Land for Sewage Purification. The most unsuitable soils for sewage purification are stiff, tenacious clays, peaty or boggy land, and certain conditions of coarse, gravelly soils, which contain hard conglomerate layers often very dense and impervious. Clay lands can be rendered more fitted for filtration by preparing specially the surface to some depth by ploughing or digging in ashes or other materials.

The land must be prepared so that it will absorb the sewage uniformly over its surface, without flooding or overflowing. This can be done by laying out the area in slopes according to the contour of the surface, and according to the nature of the soil.

After the sewage is delivered on to the land at the outfall it is distributed by main carriers, either of earthenware or concrete, or of bricks in cement. These are placed in contour, and are regulated by sluices and stops so as to command the area to be irrigated, the sewage being distributed over the surface by carriers made in the ground. Any pipe carriers underground which convey the sewage from one point to another should be kept low enough to prevent disturbance when the surface is being manipulated either with the plough or otherwise.

Systems of Sewage Distribution. There are several methods for distributing sewage over the surface of land.

In the *ridge and furrow* system the land is prepared in beds with ridges about 40 ft. apart, having slopes of about 20 ft. on each side with an inclination, according to the ground, of from 1 in 50 to 1 in 150, or even more if the ground be very impervious. The ridges have distributing channels formed so that the sewage flows over them down the slope of the plot or field to the furrow in a uniform layer or film, and any which is not absorbed passes to a lower plot.



36. CANDY'S TANK ARRANGEMENT

A. Water level B. Overflow channel C. Worm gear E. Screw-down valve F. Sludge sight-box G. Sludge pipe to well or lagoon H. Sludge exit pipe J. Squeegee for cleaning wall K. Centre sewage inlet L. Patent adjustable spreader M. Perforated revolving sludge pipe with hood and scraper N. Pivot O. Hood P. Concrete

The *catchwater* system is used more for very sidelong and irregular ground. A carrier is laid to command the area to be treated, and the sewage overflows from it at any part by temporarily stopping up the carrier. It then passes to a lower level, where a catchwater gutter, made to the contour of the land, passes it over a still lower part of the area. Main carriers vary in size, but are generally about 1 ft. to 2 ft. wide, and about 6 in. to 10 in. deep. The fall should be about 1 in 500 or 1 in 600.

Crops for Sewage. Italian rye-grass is one of the best crops for sewage, as its capacity for absorption is enormous, and it occupies the soil so as to choke down weeds, which are a source of trouble and expense on sewaged land. Osiers are very useful plants to absorb the organic impurities in sewage.

There are other plants which are capable of absorbing organic impurities, such as duckweed, sedges, common reed, flowering rush, white and yellow lilies, frogbit, water ranunculus, liverwort, sunflower, and watercress.

Precipitation. Where land cannot be obtained for the disposal of sewage by broad irrigation, one way of dealing with it is by chemical precipitation, that is, by adding to the sewage chemicals which have a deodorising and precipitating effect, so that on a small area of land the foul fluid from the outfall sewer can be converted into an inodorous effluent. Many years ago this was thought to be the solution of the sewage difficulty, but the bacterial treatment of sewage (which will be referred to later) has afforded an alternative method.

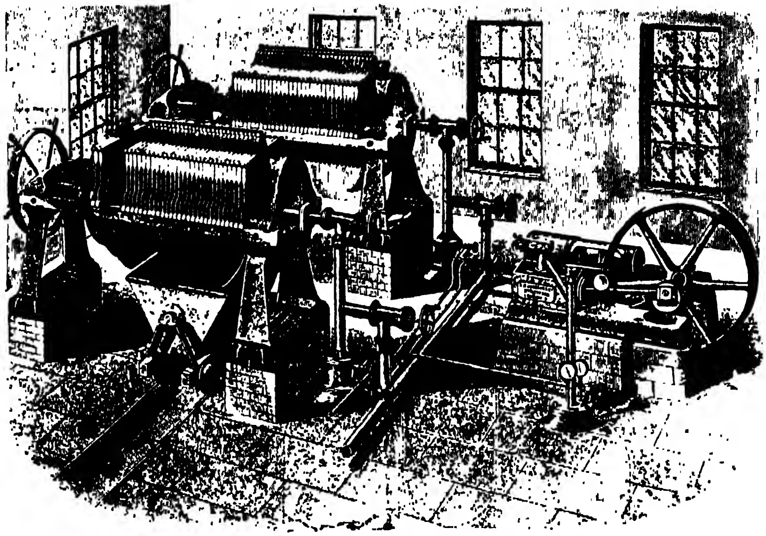
Where a considerable part of the rainfall is received into the sewerage system, provision should be made for a tank capacity of at least 50 per cent. of the average daily dry weather flow, which will give a workable margin for contingencies. Several small tanks are better than a few very large ones, as there is less risk of difficulties arising when the tanks have to be stopped for cleaning out or for repairs.

In England, shallow tanks, having a depth of about 4 ft. to 5 ft. at one end and about 6 ft. at the other, are generally used. The bottom should have a fall towards the inlet end, to which the sludge can be swept with facility. The tank is emptied by means of a floating arm which falls on drawing off the supernatant water and insures its being taken from the upper layer of fluid in the tank. A valve controls this drawing off, so that as soon as there is any appearance of floating matter in the water being let off the valve is closed and the sludge remains.

Candy's System. A recent arrangement of tank [36] by Mr. Frank Candy deserves mention. The bottom of the tank is made flat, and in the centre is pivoted a horizontal perforated pipe which reaches to the side of the tank. This is pivoted on another pipe, which is carried up to within a foot or two of the full water-level of the tank, and at that point the sludge is discharged without pumping. The pivoted pipe is revolved by hand from the outside of the tank when it is being cleaned. The perforations in the pipe being on the under side of it, and only a few inches apart, and the pipe itself being but a little above the bottom of the tank—enough to clear it—the rotation of the pipe covers the bottom, and the sludge

is drawn or sucked away from the whole of the surface. The pressure of water in the tank forces the sludge through the connecting pipe and out to a higher level, whence the sludge can be run into a sump. The perforations in the pipe are larger than the space between the bars of the screening grid. The sludge produced is thicker than the sludge usually drawn from other precipitation tanks. The removal of the sludge by this arrangement does not interfere with the flow of the sewage into the tank, and when the tank is started its working is continuous. The usual precipitants that are or have been employed are lime, sulphate of alumina, protosulphate of iron (copperas), alum, sulphate of iron, ferrozone.

Lime being a cheaper precipitant than sulphate of alumina and other chemicals, it may seem that its use necessarily produces economic results. This is, however, not always the case, as any saving in the purchase of the cheaper precipitant may be more than counterbalanced in dealing with the large volume of sludge produced.



37. S. H. JOHNSON & CO.'S SLUDGE PRESSES (Pneumatic system)

The sludge that is the result of precipitation has to be got rid of, after the tanks are cleared of it, and if it can be dug into some waste land the expense of putting up and operating what are known as *sludge presses* will be avoided.

Sludge. Sewage sludge is usually converted into a portable material in filter presses [37], made by Johnson & Co., Manlove, Alliott & Co., and others. The principle of construction consists generally of a series of circular or square iron discs, the faces of which are grooved and recessed, and are covered with a filter cloth. The plates slide on guides, and when they are close together they form a nearly cylindrical mass of discs, with hollow spaces between them into which the wet sludge is forced, generally by compressed air. The fluid passes through the filtering material to the grooved surfaces of the plates, whence it is conveyed by holes at the bottom of the inner part of the plate to the outside of the press. The solids are retained in the space between the discs, from which they are removed by sliding the plates away from each other on the guides by hand. The writer, some years ago, devised a plan for rapidly opening presses of this kind by connecting the series of discs together with links and attaching the whole to a crosshead. This was drawn along the guides, either by a knuckle-joint lever worked by hand or by a piston rod actuated by compressed air or steam, so that, as the piston rod drew the crosshead forward, it was followed by the whole string of discs.

Sludge Treatment. The sludge, before pressing, is usually stored in an iron receiver, into which it is drawn from the sludge pit by exhausting the air in the receiver. With some sludges a little lime is added for the purpose of assisting the water to filter through the cloths. The sludge is generally forced from this receiver into the interstices of the discs of the filter presses by compressed air—at from 60 lb. to 100 lb. per inch—which, being turned into the receiver, displaces the sludge. It is sometimes pumped direct from the sludge pits without a receiver. The cost of converting fluid sludge into this pressed cake is from 2s. to 2s. 6d. per ton of cake containing about 50 per cent. of moisture, in which state it represents approximately one-fifth of its original bulk.

Sludge consists of about 90 parts of water to 10 parts of solid. As it dries its weight diminishes, and the following simple rule defines this:

Let X = weight of sludge to be ascertained;
S = weight of solids in the sludge (which is constant);
P = percentage of moisture in the sludge.

Then
$$X = \frac{S \times 100}{100 - P}.$$

For instance, to ascertain what weight 25 tons of sludge containing 90 per cent. of moisture would be reduced to when it is dried to 15 per cent. of moisture:

Twenty-five tons of sludge with 90 per cent. of moisture contains 2·5 tons of solids (which is constant); therefore, applying the formula,
$$X = 2{\cdot}94 \text{ tons}.$$

Detailed descriptions of various sewage disposal works are given in the writer's book on "Sewerage and Sewage Disposal."

Continued

CHARLES STUART & HIS TIMES

Continued from page 4309

James I. and Charles I. Gowrie Conspiracy and Gunpowder Plot. The Civil War. Hampden and Cromwell. The King's Trial and Execution

By JUSTIN McCARTHY

WE must now return for a time to the history of our own country, which we have followed up to the end of Elizabeth's reign.

Queen Elizabeth was succeeded by James, the only son of Mary Queen of Scots and Darnley. But James succeeded not as the son of the Queen of Scots, but as the great-great-grandson of the English Princess Margaret, wife of James IV. James I. of England and VI. of Scotland had received much of his education from George Buchanan, the celebrated Scotch scholar, writer, and reformer. James remained in a guardianship which became a sort of imprisonment because of his extreme youth and the ambition of those who had charge of him to govern according to their own ideas; but in 1578 the Regency was taken from the Earl of Morton, and James became—at least, nominally—King of Scotland.

He had many quarrels with the clergy and the nobles during his reign, and showed a strong dislike both for the Presbyterians and for the Catholics. He seemed, for a time, determined to restore Episcopacy to Scotland, and did indeed establish bishops there. In 1585 he made a treaty with Queen Elizabeth, and he co-operated with the English against the Spanish Armada. In 1589 he married the Protestant Princess Anne of Denmark, thus allying himself with the Protestant Powers.

The Gowrie Conspiracy. In 1600 occurred the famous Gowrie conspiracy, the story of which is that the young King was hunting in Falkland Park on August 5th, when Alexander Ruthvin, brother of the Earl of Gowrie, met him, and induced James, who was always in need of money, to go to Gowrie House by telling him that a Jesuit, with a large sum of money, was a prisoner there. When James arrived he found only an armed retainer of the earl, and no Jesuit. Ruthvin then tried to kill James in revenge for the execution of the Earl of Gowrie, Ruthvin's father, in 1584. But the King managed to call to his aid Sir John Ramsay, who stabbed Ruthvin twice, and he and his brother, the Earl of Gowrie, were afterwards killed by two other followers of the King. This story, however, was, and still is, much disputed. Some said at the time that James, wishing to get rid of the Ruthvins, had arranged the whole affair; but it seems certain that there was a conspiracy among them to carry off or kill the King. It was said, also, that Queen Elizabeth was privy to the plot.

When James came to the throne of England, in 1603, he was well received by the people in general, but he soon made himself disliked. Mr. Green says: "No Sovereign could have jarred against the conception of an English ruler, which had grown up under the Tudors, more utterly . . . His big head, his slobbering tongue, his quilted clothes, his goggle eyes, stood out in as grotesque a contrast . . . . as his gabble and rhodomontade, his want of personal dignity, his coarse buffoonery, his drunkenness, his pedantry, his contemptible cowardice;" but "under this ridiculous exterior was to be found a man of much natural ability, with a considerable fund of shrewdness, mother wit, and ready repartee."

He had much literary ambition, and wrote various essays and tracts, one being the famous "Counterblast to Tobacco," a treatise published in 1604, and intended to discourage the practice of smoking, then recently introduced into England.

Gunpowder Plot. James was always under the influence of some favourite, the best known being the Duke of Buckingham. On them he lavished titles, offices, peerages, and emoluments of every kind, while to relieve his own immediate wants he degraded the prerogative of the Crown by the actual sale of titles to rich and ambitious men. In 1604 the abortive Gunpowder Plot was devised, its object being to spring a mine under the Houses of Parliament on a day when the King would be present in the House of Lords, and when the Commons also would be assembled, and thus to annihilate the King, Lords, and Commons at one fell swoop. The plot was devised by Robert Catesby, a Catholic of good family and fortune, who had been fined and imprisoned for his faith. Several other men of high family were undoubtedly concerned in the plot, which was discovered in time by an anonymous letter written to Lord Mounteagle. A search was made, and Guy Fawkes was discovered in some vaults under the House of Lords, which had apparently been hired for some supposed, and not unlawful purpose, and in which the mine had been prepared to explode at a given signal. Catesby and some others fled on the discovery of the plot and sought refuge, but were pursued by soldiers and killed. Guy Fawkes and some others were executed in the January of the following year.

"The Wisest Fool in Christendom." The reign of James was made up of continual struggles against his Parliaments, and against the principles of the Reformation. He was an advocate of the Divine Right of Kings, and though he often spoke and wrote in favour of constitutional liberty, he was in practice an opponent of all such theories. Sully, the great French statesman, soldier, and author, called James "the wisest fool in Christendom." Macaulay, in one of his flashing epigrams, describes him

as "made up of two men—a witty, well-read scholar, who wrote, disputed, and harangued, and a nervous, drivelling idiot who acted."

James died on March 27th, 1625. His reign was, in almost every sense, unfortunate for his country as well as for himself, and the utmost one can do is to excuse him because of his bringing up, because of the unsuitable position to which his elevation to the throne brought him, and because of the fatal weaknesses of his intellect and character. He might have had a meritorious career if he had never been called to a throne.

Charles I. His son, Charles I., was born in Scotland on November 19th, 1600. In his childhood and early boyhood he was delicate. This, however, he soon outgrew, and became not only proficient in all physical exercises, but a scholar of much distinction. He became Prince of Wales in 1616, and negotiations were soon in progress for his marriage with a Spanish princess, and it was for this reason that Charles, under the influence of his father's favourite and his own, the Duke of Buckingham, made his romantic expedition to Madrid in the disguise of an ordinary traveller to see for himself whether the princess was likely to prove to his taste. He found that the Spanish Court and the Papal Government would never allow a Spanish princess to become the wife of any but a Catholic, and Charles would not accept these conditions. We may assume that devotion to his own faith was the main cause of this resolve.

Charles came back to England filled with bitter resentment against Spain. The English people gave him a generous welcome when he returned, on account of his devotion to the principles of the Reformation. But the public sentiment was soon changed by the news of his betrothal to the French Princess, Henrietta Maria, sister of Louis XIII. of France, and the discovery that the marriage articles made it an obligation on him to allow his intended Queen the free exercise of her religion and the care of any children of the marriage until each had reached the age of thirteen. The marriage, which was carried out soon after his accession to the throne, was a happy one. But Charles became, as years went on, more and more dependent on the counsels and the influence of his wife.

The Duke of Buckingham. He had been for a long time under the influence of the Duke of Buckingham, but Buckingham made so many mistakes in home and foreign policy that he became intolerable to the English people, and in August 23rd, 1628, he was assassinated at Portsmouth by John Felton, a dismissed officer. This act was partly one of fanaticism and partly of private vengeance.

After the death of Buckingham, Charles was more than ever under the influence of the Queen in his public policy, and, mainly under her direction, he tried to make himself absolute ruler of the State. Even when in the conditions of the times some course he proposed to take might in itself be justified, he made the mistake of endeavouring to carry it by his own decision instead of through the authority of Parliament. During the first four years of his reign three Parliaments were summoned and dissolved.

The Petition of Right. In the last of these, that of 1628, Charles was compelled, after a long struggle, to assent to the famous Petition of Right, demanding four things: "(1) That no freeman should be obliged to give any gift, loan, benevolence, or tax without common consent by Act of Parliament. (2) That no freeman should be imprisoned contrary to the laws of the land. (3) That soldiers and sailors should not be billeted in private houses. (4) That commissions to punish soldiers and sailors by martial law should be revoked, and no more issued." To this, Charles at first replied evasively, but was in the end compelled to assent. Then followed an interval of eleven years, during which he summoned no Parliament, but ruled according to his own authority, supported by subservient Ministers, judges, and courts of law.

His greatest difficulty was to get sufficient money to maintain his Court and his policy. He allowed himself to be drawn into some futile quarrels with France and Spain, which ended in a patched-up peace, but cost him a considerable amount of money, and from which he tried to retrieve himself by increased taxation at home.

One of these taxes was that of Ship Money, which imposed on various cities and counties of England the obligation of providing funds to maintain a certain number of ships and men. It was an old tax which had been levied to maintain a navy to oppose the Danes, and had passed out of use for many generations. Charles revived it on his own authority, and the Court of the North and the Star Chamber fined and imprisoned those who resisted demands the legality of which was doubtful, although Charles obtained in 1635 from ten of the judges the opinion that the tax was lawful. It was met with a determined resistance by John Hampden, a distinguished patriot, whose trial for refusing to pay the tax began in 1637.

Beginning of the Civil War. At the same time that this tax made the King unpopular he was pursuing an ecclesiastical policy which was contrary to the feelings of the people in general, and his attempt to impose an English Church Service on the Scotch Presbyterians led to risings in that country. The attempted arrest of the five members of Parliament—Hollis, Hazlerig, Hampden, Pym and Strode—on an accusation of high treason, in January, 1642, combined with these other causes to bring about a rebellion. [See FRONTISPIECE, Part 31.] Charles left London to prepare for war, and on August 22nd he raised the Royal Standard in Nottingham, and thus the great Civil War began. Charles led his army in person, and showed great courage with some military skill. But he had set the great mass of the people against him by his autocratic conduct; and soon there came into the field against him Oliver Cromwell, the man who was destined to be his most formidable antagonist.

Cromwell, like Hampden, had sat in the House of Commons, and, although he had no gift of eloquence and never became a Parliamentary

orator, his opposition was powerful. But his real gifts came out when he entered the army and fought as captain of a troop of horse at Edgehill and in other battles.

Cromwell's Ironsides. Then it was that he organised his famous Ironside troops, whom he taught to combine rigid discipline and resistless military force with strict personal morality and with political enthusiasm. At the battle of Marston Moor, near York, on July 2nd, 1644, he opposed Prince Rupert, who commanded the right wing of the Royalist army, himself a brilliant and reckless cavalry leader. Cromwell, at the head of the army trained and disciplined by himself, won a complete victory over his opponent, and from this defeat the cause of Charles never really recovered. The battle of Naseby (June 14th, 1645), in which Charles himself took part, ended in the hopeless destruction of his army and his cause, and in less than a year he surrendered to the Scottish army at Newark, and by them was handed over to Parliament. He was imprisoned for a time, but escaped; was again made captive, shut up in Carisbrooke Castle in the Isle of Wight, and finally brought to trial at Westminster.

Charles behaved then, as at many other periods of his eventful reign, with dignity and courage. Three times he refused to plead, declaring that the Court had no authority or capacity to try him. But such a declaration was futile before a court that had been created for the distinct purpose of his condemnation. He was in the hands of his enemies, whom he had made such by his arbitrary conduct; but it must have been evident to everybody that no pleading, and no defence which he could have made, would in any case have affected the decision of his judges.

A Great Declaration in Parliament. Behind the Court, and all the civil authorities, was the army which had fought against and conquered him. The House of Commons, where there was still a majority of members in favour of Charles, had been put through a process ever since known as "Pride's Purge." Colonel Pride, with a list of names in his hand, prevented those known to be in favour of the king from entering the House, and imprisoned any who resisted him. One hundred and forty members were forcibly expelled, and it was then that the resolution was passed to bring Charles to trial, and to nominate the Court. The House of Commons, thus newly constructed, passed a resolution—"That the people are, under God, the original of all just power; that the Commons of England in Parliament assembled—being chosen by, and representing, the people—have the supreme power in this nation; and that whatsoever is enacted and declared for law by the Commons in Parliament assembled has the force of a law, and all people of this nation are concluded therebye, although the consent and concurrence of the King or House of Peers be not had thereunto."

This declaration foreshadowed the coming of that Commonwealth which was for a time to set aside the monarchy. But it was not a Parliamentary declaration in the true sense, and only came from a House of Commons reduced by force to the necessity of adopting it. The power behind the tribunal which tried Charles was not that of Parliament, but of the army. Charles had committed actions which no Parliament and people worthy of freedom could possibly endure; but the declaration exacted from the House of Commons was in its meaning a demand for the foundation of a republic, and the demand was, for the time, soon to be satisfied.

The Trial and the End. Charles faced his judges with calm and dignified courage. It was one of the finer qualities of his nature that upon a really great occasion he was able to shake off the hesitancy and vacillation which he so often showed in the ordinary business of life; and when he stood before the tribunal constituted to pronounce his sentence of death he presented as picturesque and dignified a figure as the art of the painter or the sculptor could have reproduced. Although Charles had denied the competence of the Court and had refused to plead, the trial lasted for several days, and numbers of witnesses were examined to prove the truth of the charges made against him. Charles was found guilty and was sentenced to death as a tyrant, traitor, murderer, and enemy of his country. On January 30th, 1649, he ascended the scaffold which had been erected at Whitehall, and was awaited there by two masked executioners. He bore himself with stately and superb composure, and one stroke of the axe brought his death. On February 7th, 1649, he was carried to his grave in Henry VIII.'s vault at Windsor.

The King's Mistakes. The whole story of Charles's reign was a struggle between the principle of absolute monarchy and the principle of republican government. Charles committed many errors as a ruler and as a man, but he was not a worse sovereign than many of his predecessors who were never brought to trial. He had miscalculated his own power when he asserted himself the master of his Parliaments, while he did nothing to conciliate the great mass of his people. He turned against him an army which a more judicious despot might have found means to hold for ever on his side. He had the will but not the capacity to be an absolute despot. He allowed himself to be ruled by favourites; but where the policy of the favourite failed, as in the case of Strafford, he had not the nerve to stand by him to the last. Charles sacrificed Strafford—who, whatever his faults, was at least devoted to his Royal master—to his fears of a popular rising. He turned Churchmen and Dissenters against him; he made Scotland and Ireland hostile to his rule; he failed to appreciate the genius, popularity, and the rising power of Cromwell, and brought upon himself the ruin which he might have diverted by displaying a spirit of fairness and of justice.

He left six children behind him, two of whom, Charles and James, were destined to succeed him when the Commonwealth of Cromwell had passed out of existence.

Continued

Group 16
FOOD SUPPLY
11

SUGAR
continued from page 4455

SUGAR ANALYSIS & GLUCOSE

The Polariscope and How to Use it. Making and Refining Glucose or Starch Sugar. Testing. Plant Required. Commerce of Sugar

THE chief analytical operations required deal with the density of juices and syrups, the amount of sugar in a given sample of sugar, the proportion of glucose, the moisture, the soluble and insoluble ash, and the rendement.

Density. Density is conveniently taken by means of an instrument known as a *hydrometer*, the method in which a specific gravity bottle is employed being too lengthy for general use. The two hydrometers in ordinary use are the Baumé and the Brix, or Balling. The latter is preferred, as the graduations of the scale give close approximations to the percentage of total solids present; 10° Brix, for example, in a clean juice indicates 10 per cent. of sugar. The hydrometer is a long glass bulb with a slender spindle so weighted with mercury at the lower end that it maintains the upright position when immersed in a liquid. The spindle is graduated and the instrument sinks or rises in the liquid in relation to the density; the point at which the liquid cuts the spindle being read off on the scale indicates the degree.

Principles of the Polariscope. The amount of sugar in raw sugar is determined by the *polariscope*, the degree of polarisation being the basis upon which sugar is bought and Customs duty levied. A ray of light is capable of being reflected or refracted in any direction; but if a ray of light be placed under such conditions as will restrict its vibrations to one particular direction it is said to be *polarised*. There are several ways by which light can be polarised; in the instrument with which we are dealing the method adopted is that of double refraction. There are certain substances—Iceland spar, for example—which have the power of splitting up a ray of light into two others of equal intensity, the phenomena being known as *double refraction*. [See PHYSICS.] In a crystal of Iceland spar the line connecting the points at which the three obtuse angles meet is the principal axis; if a ray of light be passed through the crystal parallel to this axis, it is not split up; if, however, the position of the crystal be altered, the emerging ray is found to be divided into two. The degree of separation depends upon the angle through which the crystal has been turned; when this angle amounts to a right angle, the separation is at its greatest, and if the crystal be still further turned through another right angle, they coincide [26]. For polarimetic observations, only one of the rays is used, the other one being thrown completely out of the field of view by means of a *Nichol's prism.* This is a crystal of Iceland spar the terminal faces of which are cut obliquely so as to give the new faces an inclination of 68°. The whole crystal is then divided into two at right angles to the new faces, and the faces are then polished and cemented together with Canada balsam.

26. THREE APPEARANCES IN THE POLARISCOPE

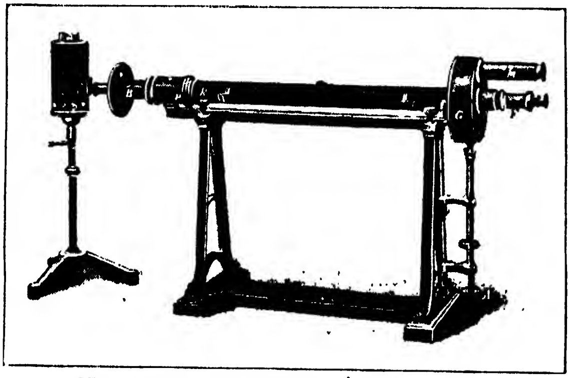
Polariser and Analyser. In examining a polarised ray it is necessary to make use of a second Nicol's prism, placed in such a position that its optical axis is in a line with that of the first. The two prisms are then termed the polariser and the analyser. If an ordinary ray of light be passed through the polariser and then through the analyser, it is refracted in the direction of an extraordinary ray, and emerges from the analyser in that condition. If the plane of polarisation or analyser be so adjusted that it is at right angles to the plane of the polariser, no light will leave the analyser, because the ray, after passing through the polariser and entering the analyser, takes the direction of the ordinary ray, which is absorbed in the case of the prism. If the analyser be rotated to the extent of 180°, the same thing happens; at intermediate positions the field of vision becomes more or less illuminated.

If a ray of light be passed through a plate of quartz (cut at right angles to the axis of the crystal) it is separated into two rays, which proceed in opposite circular directions; such a ray is said to be circularly polarised, and is designated right-handed or left-handed, as the case may be. If a plate of quartz be displaced between two Nicol's prisms when their planes of polarisation are at right angles to each other, a red light is seen; the angle through which it is necessary to rotate the analyser to make the field again non-luminous is termed the *angle of rotation.* Of the several types of polariscope the *half shadow* instrument is the one preferred. The principal feature of this type is the division of the circular field of vision into two halves. When the vernier is placed at zero the two halves of the field are uniform in shade. If an observation tube be filled with an optically active liquid such as a solution of sugar and placed between the polariser and analyser, the equilibrium is destroyed, the result being that one half of the field becomes dark and the other half bright; the analyser is then turned to the right of the right half beshaded, or to the left of the left half beshaded, until the field is once more of a uniform shade; the rotation is then read from the scale.

Schmidt and Haensch's Polariscope. The form of polariscope or saccharimeter in use in the British Customs Department and the United States Internal Revenue Bureau is that of Schmidt and Haensch, Berlin. This instrument is adapted for use with white light illumination from coal gas. It is convenient

and easy to read, requiring no delicate discrimination of colours by the observer. It is adjusted to the Ventzke scale, which may be defined as "such that the degree of the scale is one-hundredth part of the rotation produced in the plane of polarisation of white light in a column 200 mm. long; by a standard solution of chemically pure sucrose at 17·5° C., the standard length of sucrose in distilled water being such as to contain at 17·5° C. in 100 Mohr's c.c. 26·048 grammes of sucrose." The instrument should be adjusted by means of control quartz plates, three different plates being used for comparative adjustments, reading approximately 100, 90, and 80 degrees on the scale respectively.

A Description of the Polariscope. The illustration [27] shows the latest form of this polariscope. The tube B contains the illuminating system of lenses; the polarising prism is at P, and the analysing prism at G. F carries a small telescope through which the field of the instrument is viewed, and just above is the reading tube M, which is provided with a mirror and magnifying lens for reading the scale. The tube containing the sugar solution is marked R. To use the instrument the operator seats himself with his eye level with the tube F, which tube is moved in and out until the proper focus is secured so as to give a clearly defined image, when the field of the instrument will appear as a red luminous disc, divided into two halves by a vertical line passing through the centre, and darker on one half of the disc than on the other. If, now, the milled head A be rotated first one way and then the other, the appearance of the field changes, and at a certain point the dark half becomes light and the light half dark. By rotating the milled head delicately backwards and forwards over this point, the exact position when the field is neutral or of the same intensity of light in both halves can be found. When the milled head is set at the point which gives the appearance of the centre disc in figure the eye of the observer is raised to the reading tube M and the position on the scale noted. On each side of the zero line of the vernier a space corresponding to nine divisions of the movable scale is divided into ten equal parts enabling fractional parts of a degree to be indicated.



27. SCHMIDT AND HAENSCH POLARISCOPE

Method of Manipulation. Begin by weighing out 26·048 grammes of sugar, dissolving it, clarifying the solution, making it up to standard volume (100 c.c.), and filtering and filling the observation tube, regulating the illumination and making the polariscope reading. The sugar is conveniently weighed in a counterpoised nickel or German silver flask with a large lip, whence it is readily washed into the flask. The solution, before being filled up to the mark, is clarified by the addition of lead subacetate or phospho-tungstic acid until no further precipitate takes place. Filtration and clarification may often be made easier by adding a few drops of suspended aluminic hydrate after the lead. The flask is filled with pure water until the lower line of the meniscus coincides with the mark on the neck. The mouth of the flask is closed and its contents well shaken and poured on to a folded filter; the first few cubic centimetres of the filtrate are rejected. The subsequent filtrate, if not perfectly clear, is returned to the filter until it shows no cloudiness. The polariscope tube is then filled and placed in the polariscope, the scale of which, after neutralising the rotation produced by the sugar by turning the analytical prism of moving the quartz wedge, will give the percentage of sucrose in the sample taken. A dark solution may either be read in a 100 mm. tube or decolorised by bone black. A weak solution may be read in a longer tube.

Estimation of Glucose. The reagent required for estimating reducing sugar is known as Fehling's solution. Take 34·64 grammes of pure crystallised sulphate of copper, and dissolve it in 200 c.c. of distilled water. Also take 187 grammes of tartrate of soda and potash and 78 grammes of caustic soda, and dissolve in 500 c.c. of distilled water. Add the copper solution to the second solution, and make up to 1,000 c.c. with distilled water. The copper in 10 c.c. of this solution is completely reduced by 0·05 gramme of glucose, which is shown by the blue copper solution turning red and throwing down a precipitate of red copper oxide. To make the estimation, place 10 c.c. of the Fehling solution in a flask over a Bunsen burner, and make it boil. Then from a graduated tube (burette) run in a few cubic centimetres of the sugar solution, again boil, and note if any blue colour remain in the liquid. If there be still some blue liquid over the red precipitate, run in more sugar solution until all the blue colour has disappeared. From the number of cubic centimetres of sugar solution required, the amount of glucose is determined by calculation. The best results are obtained when not less than 10 c.c. or more than 50 c.c. of sugar solution are needed for 100 c.c. of Fehling solution, and after making a rough estimation the strength of the solution is adjusted to conform with these requirements. The strength of the copper solution can be checked or

standardised by comparing it with a solution of pure invert sugar, prepared by heating cane sugar solution, with a few drops of sulphuric acid to invert it.

Moisture. Weigh from two to five grammes of the sugar into a flat-bottomed nickel or platinum dish, and dry at a temperature of 100° C. for three hours. Cool in a desiccator and weigh; return to the oven and dry for an hour. If, on weighing, there be only a slight change in weight, the process may be considered finished; otherwise the drying must be continued until the loss of water in one hour is not greater than 0·20 per cent. From the quantity of loss of weight of the sample taken the amount of moisture or water is calculated.

Ash. Take five or ten grammes of sugar in a platinum dish, heat at 100° C. until the water is expelled, to allow the action to take place slowly, and finally heat in a muffle to low redness. Then, by weighing the ash that is left, the percentage of ash in the sample is obtained. The quantity of soluble ash is estimated by digesting the ash with water filtering through a Gooch crucible, washing with hot water, drying the residue at 100° C., and weighing. The difference in weight from the above determination equals the soluble ash.

Rendement. Rendement is the French term for the net amount of sugar in a given sample of raw sugar. It is deduced from the fact that each 1 per cent. of ash in the raw sugar prevents 5 per cent. of sugar from crystallising, and each 1 per cent. of glucose causes an equal amount of sugar to be retained in the molasses. Hence, from the amount of sucrose shown by the polarimeter deduct five times the weight of ash plus the weight of the glucose present, and the refining value, or rendement, is obtained. For instance, a sample of sugar polarised 93 per cent., the glucose was 2 per cent. and the ash 1 per cent., $93 - (1 \times 5 + 2) = 86$ per cent. of available sugar.

Sugar of Milk. The source of sugar of milk is the whey from cheese factories or the skim milk from creameries. As separated from milk, it is a white crystalline mass which appears in commerce in thick sticks. Switzerland for many years controlled the milk sugar industry and supplied the markets of the world, although small quantities were made in other countries—for example, Germany. Between 1880 and 1890 the manufacture was taken up in the United States, and the industry grew so that by 1895 some milk sugar was exported to Great Britain and Germany. Enormous quantities are now made, one factory in Illinois turning out 16 to 18 barrels (225 lb. each) a day. The Swiss process of manufacture on a large scale is to evaporate 50,000 litres of whey to dryness, a residue of about 1,250 kilos being obtained. This is dissolved in water at 65° C. in a copper pan, ½ kilo to 1 kilo of alum added, the solution filtered through animal charcoal, boiled down to a syrup, and allowed to crystallise on cords or sticks. It is purified by recrystallising and repeated precipitation by alcohol. The best grades are used in food and pharmacy. The methods of evaporating the whey vary from open boiling pans to expensive vacuum boilers such as are used in cane sugar making. Filter presses like those described in the article dealing with beet sugar making are also employed.

That maker whose process of making milk powder consists in allowing milk to trickle on huge metal drums heated from the interior prepares milk sugar from it by simple solution in water. The casein of the milk, which is the other chief constituent of milk, is rendered insoluble by the heat, and is left behind when using water for extracting the sugar.

Ramage's method consists in evaporating slightly alkaline whey to half its bulk, adding an acid to remove the casein, and then, after further concentrating, precipitating the milk sugar by adding methyl alcohol.

In Kennedy's process the milk is concentrated to between 11° and 27° Baumé, and the product chilled to 32° F. until the sugar crystallises. The crystals are removed by submitting the liquid to centrifugal action, and washing with cold alkaline water.

Glucose, or Starch Sugar. Enormous quantities of glucose are manufactured and used in the manufacture of confectionery, jams, beer, golden syrup, and for other purposes in the industries. Allegations have been made as to the wholesomeness of glucose as an addition to articles of food. The matter was investigated by the National Academy of Sciences at Washington, and the committee of chemists who examined the conditions of the industry reported that, provided no objectionable substance were used in the manufacture of glucose, the product was quite wholesome and unobjectionable. It was the use of sulphuric acid contaminated with arsenic for converting starch into glucose that caused the remarkable "arsenic in beer" scare of 1904. The use of glucose as a preservative of jams, in the sense that it prevents the crystallisation of the cane sugar, seems a legitimate use of the substance, but it should not be forgotten that, as glucose is cheaper than cane sugar, it is not inconceivable that cases may arise in which an illegitimate profit may result, to the prejudice of the consumer.

The starch used is extracted from maize, potato starch, sago and rice starch, and is converted into glucose by heating it under pressure with weak acid. This process being complete the acid is neutralised, and the product filtered and evaporated in a similar manner to that employed in refining sugar.

Manbré's Process. In Manbré's process place in a converter 56 lb. of sulphuric acid of a density of 66° Baumé, add 560 gallons of water, and heat to 212° F. Into a wooden vat provided with steam pipe and stirring apparatus place 560 gallons of water and 56 lb. of sulphuric acid, heat to 85° F., and add one ton of starch. Mix well, and raise the heat to 100° F.; then pour the diluted starch into the converter containing the boiling diluted sulphuric acid and blow in steam to raise the temperature to 320° F., equivalent to a pressure of six atmospheres. When this

temperature is attained, open the cock of the distilling pipe and let the steam escape, when it will carry the volatile matters out of the converter with it. Test the mixture with iodine to find out whether all the starch be converted, no blue colour being obtained when this result is attained, and also with silicate of potash and lead acetate for absence of dextrine, no turbidity being given in the absence of dextrine. It takes two to four hours for conversion. Run the liquor into the neutraliser, and add lime to combine with the acid, and pass in carbonic acid gas to precipitate the remaining lime. Filter the liquor, and evaporate to 20° Baumé. Clarify in a blow-up pan with charcoal, again filter, and evaporate to 28° Baumé for glucose syrup, or 38° Baumé for hard glucose. This process is still followed in some factories; but the modern practice, as used in the United States, was the subject of a paper before the Institute of Brewing by Messrs. G. W. Rolfe and G. Defreu, from which the following particulars are taken.

Glucose Manufacture in the United States. Maize is placed in steeptubs capable of holding 2,000 bushels or more. Water at 150° F. is added and the steep allowed to cool to 90° F. Sulphurous acid is added to prevent putrefaction and to assist softening, and the steeping is continued for from three to five days. The separation of starch is brought about by grinding the wet grain mixed with water, separating the starch grains from the woody pulp and germ by washing through rapidly shaken sieves of bolting cloth, and settling out the starch from the gluten by subsidence while passing over gently inclined runs, called "tables," resembling a bowling alley. In many factories the germ is removed separately by a special process.

The starch collected on the runs, and containing about 50 per cent. of water, is mixed with water to a thick cream of 20° Baumé, and then converted with hydrochloric acid in large copper boilers at a steam pressure of about 30 lb. The amount of acid used is about 0·0006 of the weight of the starch. In some factories sulphuric acid is used, and seems to be advantageous, in the manufacture of candy goods. Oxalic acid and hydrofluoric acid are also sometimes employed. The point of conversion is controlled by the disappearance of the dextrine precipitate when the liquid is poured into alcohol. In making syrup glucose, the acid is mixed with about fifty times its bulk of water, and run into the converter. Steam is then turned on, and pressure maintained at 30 lb. while the starch-milk is being pumped into the boiler, which takes about half an hour, and the heating is continued after this for 40 minutes or more. The degree of conversion is, in this case, entirely controlled by the iodine test. As soon as the conversion is complete the liquid is blown out into the neutraliser, where sodium carbonate is added. The neutralisation is a process of great delicacy, as any excess of acid or alkali will seriously affect the refining operations which follow. Properly neutralised liquor should show only the acidity caused by carbon dioxide or the weakest vegetable acids. It is of a clear, bright amber colour, and contains large flocculent masses of coagulated gluten, which, in a test-tube, form a layer of about half an inch thick. When the proper point of neutralisation is attained, this layer is greenish-drab, owing to the precipitated iron.

Refining Glucose. The refining process is, in general, similar to that of sugar. *Glucose liquors* are, as a rule, put twice over bone black (free from ammonia or caustic lime) first at their original concentration of about 18° Baumé, and again after concentration to 28° to 30° Baumé, the denser syrup going over fresh black. The revivifying of the bone black is carried out on lines similar to those of sugar. The *heavy liquor* goes direct from the filters to the vacuum pan in most modern factories, and in this final concentration sulphites are added in amounts varying from 0·008 to 0·050 per cent. of sulphurous acid. The function of these sulphites is to prevent oxidation and consequent coloration due to the formation of caramel-like bodies, to bleach ferric salts as a prevention of fermentation of low, concentrated products, and as a preventive of oxidation of candy goods in the candy kettle. Confectioners' goods are more heavily "doped" than others.

In refining *grape-sugar* liquors, the concentrated syrups are drawn off into pans or barrels, and allowed to solidify, a seed of crystallised sugar being often added to facilitate crystallisation.

Anhydrous grape-sugar is made in a similar way to the syrup, which is refined at lower concentrations throughout the process in order to obtain a purer product. When crystallisation is complete, which takes about three days, the sugar is purged in centrifugals. Glucose syrups are made of six concentrations—39°, 41°, 42°, 43°, 44°, and 45° Baumé. Mixing goods are generally finished up to 39° or 41° Baumé, the latter being the grade usually sold to brewers. The higher concentrated products are used by confectioners and are characterised by a greater perfection of refining and a large amount of sulphites. They are frequently "whitened" with a little methyl violet.

Testing Glucose. A well-refined glucose is practically colourless and clear. If a white glass cylinder be filled with glucose, its colour, as well as any turbidity, may be seen. If the colour be a pure white the sample is dyed, as can be proved by exposing to the light for a few days, when the darkening which all glucoses undergo disturbs the colour balance, and the presence of dye is made more evident. If no dye be present the glucose, unless quite turbid, will show some colour, usually green or yellow. These tints are almost invariably present, and seem to be caused by traces of iron salts and vegetable colouring matters. They are of little consequence, except as indicators of the thoroughness of the refining and the removal of albuminoids and oil, which affect the colour of the product. As to turbidity, cloudiness caused by faulty conversion, separation of dextrins, or sugar, is of rare occurrence. A smoky appearance is

often caused by bone-black rust, or, in some cases, by iron sulphide when a large quantity of new black is used in refining. These, of course, are the results of improper preparation of the black. White cloudiness is caused either by calcium salts or by organic growth due to fermentation. The valuation of solid starch sugars is practically based on their dextrose content. Whiteness, of late years, seems to be more of a desideratum than formerly; hence the practice of dyeing is becoming common. The principal mineral impurity is iron, which, however, is rarely present in more than traces. A delicate test for it is *cochineal.* Sulphites must be first removed and the solution made neutral or faintly alkaline. If iron be present the crimson of the cochineal gradually passes to violet. For some purposes glucose is tinted with caramel to make it resemble cane sugar.

Glucose Manufacturing Plant. We now describe the plant used for making glucose. Two open converters for receiving the starch liquor from the settling tanks, or two wooden vessels, should measure 5 ft. 9 in. in diameter, 8 ft. 9 in. deep, be secured by bands on the outside, be lined with thin sheet copper, and be provided with a copper heating coil and agitator.

The closed converters consist of two copper cylinders 5 ft. in diameter and 12 ft. deep, with closed ends ½ in. thick and shell ⅜ in. thick, with the necessary inlets and outlets for liquor and steam and condensation, and copper coil, also the safety valve and pressure gauge.

The bag filters should be of the Taylor type, and have a capacity of filtering 10,000 gallons in 10 hours.

The animal char department should consist of four cast-iron filters 4 ft. in diameter and 18 ft. long, in three or four lengths, and have the necessary inlets for different liquors, washwater and steam, also the liquor outlets.

The revivifying kilns should consist of 14-pipe kilns with a capacity for revivifying 10,000 lb. of bone black per day of 24 hours.

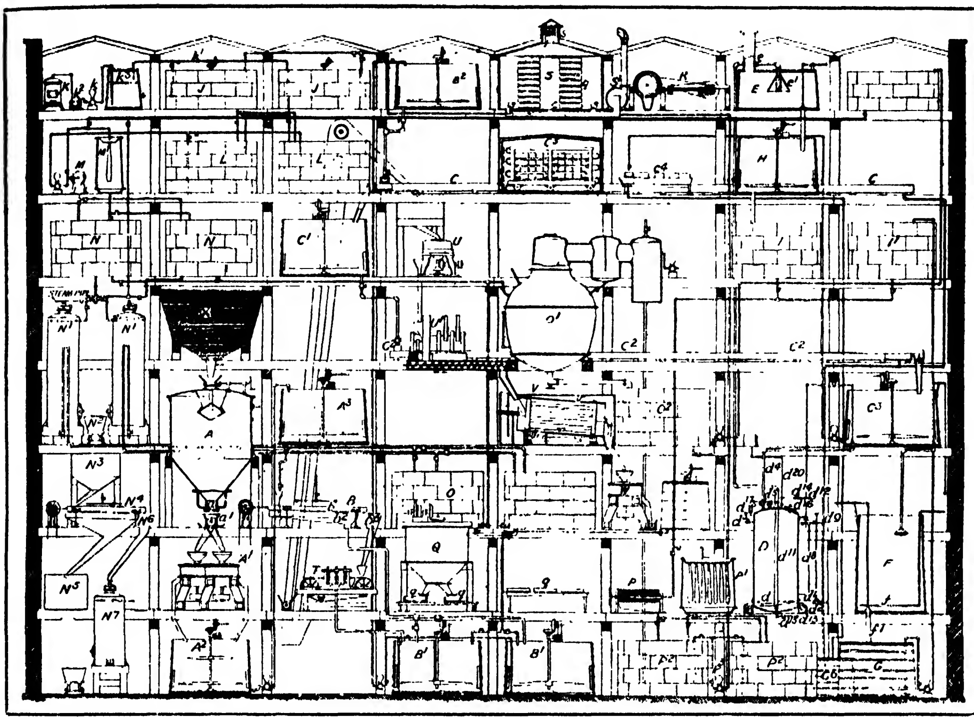
Elevators are necessary for conveying the char from the kiln to the receiving tank, which will supply the four char filters.

Concentrating plant should be the triple effet type, the vacuum pan to be a copper pan 5ft. 6 in. in diameter with 5 ft. depth of curb, incline bottom, dome, overflow and condenser, arranged to work on the dry system; the heating surface of the pan to consist of three 2½ in. seamless copper coils held in position by braces thoroughly bolted within the pan. All bolts within the pan to be of Muntz metal; the bottom of the pan to have four lugs so as to rest upon the beams of the building.

Complete Plant for Making Glucose. The illustration [**28**] is a sectional elevation of a factory described by W. T. Jebb, Buffalo, New York (4094 of 1882). A shows steeping vat, *a* discharge spouts, A^1 disintegrating or crushing mills, A^2 agitating vats, A^3 another set of agitating vats, B separating machine, *b* shaking-sieve, b^2 receiving hopper or receptacle, b^3 separator for coarse offal, B^1 settling vats, B^2 agitating vats, C tables or runs where the starch is deposited, C^1 mixing tub, C^2 another set of starch tables or runs, C^3 tub for grading starch, C^4 draining box, C^5 dry kiln, C^6 refuse cistern, D closed converter, *d* perforated steam coil, d^1 pipe for admitting steam, d^2 valve, d^3 steam outlet pipe, d^4 pipe for conveying liquid to converter, d^5 valve, d^6 and d^7 test cocks, d^8 pipe, d^9 steam pipe, d^{10} valve, d^{11} blow-off pipe, d^{12} and d^{13} steam pipes, d^{14} and d^{15} globe valve, d^{16} manhole, d^{17} steam gauge, d^{20} pipe, E blow-off tank, *e* vent pipe, F tank or vat, f^1 pipe to G neutralising tank, H neutralising tank, I settling tank, J bleaching tanks, *k* furnace, K pump, k^1 pipes, k^2 cooling vessel, k^3 washing vessel, L receiver, M filters, M^1 bag filters, N receiving tank, N^1 bone black filter, N^2 conveyer, N^3 hopper, N^4 shaking sieves, N^5 box receiver, N^6 spout, N^7 steam tank, O tank, O^1 vacuum pan, O^2 receiving tank, P press filters, P^1 bag filters, Q cooling apparatus, *q* pans or moulds in which the glucose hardens, R cutting machine, S drying chamber, S^1 suction fan, T horizontal rollers, U centrifugal machine, U^1 disintegrating machine, V drying apparatus, *v* steam jacket, v^1 rollers, v^2 steam supply pipe, v^3 rotating pipe, v^4 branches, v^5 space between walls of steam jacket, v^6 hollow head, v^7 openings, v^8 tubes, v^9 steam pipes, v^{10} condensed steam discharge, v^{11} strips or buckets, v^{12} cylinder casing, v^{13} inlet openings, v^{14} suction fan, v^{16} hood terminating in tube, v^{16}, connected with chess-hopper, v^{17} tube, v^{18}, v^{19} and v^{20} hoppers, v^{21} feed roller, W disintegrating mill, X storage bins.

The Bounty System. It has been the practice of European countries to give bounties to the manufacturers of beet sugar on all sugar exported, the idea being to stimulate the industry in the countries where bounties were given. This policy had the effect of making sugar for local sale more expensive, and of depriving the people of a nutritious food. Sugar refiners also felt the effects very severely, and the West Indian cane sugar industry was affected. This, and countervailing duties on sugar imported into India, brought matters to a head, and a conference was called in 1898, which ended in the *International Convention,* which has for its object the equalising of the conditions of competition between beet and cane sugar, and the promoting of the consumption of sugar.

The Sugar Duty. The Finance Act, 1901, imposed an import duty on sugar and sugar-containing articles as from April 19th, 1901. The following are the chief rates: sugar of a polarisation exceeding 98 deg., 4s. 2d. per cwt.; sugar of a polarisation not exceeding 76 deg., 2s. per cwt. The intermediate duties are calculated from these charges. Molasses and invert sugar, if containing 70 per cent. or more of sweetening matter, 2s. 9d. per cwt.; if containing less than 70 per cent. and more than 50 per cent., 2s. per cwt.; not more than 50 per cent., 1s. per cwt.; glucose, solid, 2s. 9d. per cwt.; glucose, liquid, 2s. per cwt. The imposition of sugar duty involves also duty on blacking, candied peel, caramel, cattle foods



28. COMPLETE PLANT FOR MAKING GLUCOSE

containing molasses, cherries, chutney, sugared coconut, confectionery, crystallised flowers, canned or bottled fruit containing syrup, preserved ginger, marmalades, jams, sweetened spirits, marzipan, condensed milk, Nestlé's milk food, soy, and tamarinds.

Effect on Price of Sugar. The effect of the Convention and Sugar Duty, combined with a shortage in the Continental beet sugar harvest, has been to raise the price of sugar in Great Britain, and to affect businesses which depend largely upon cheap sugar. The following table from De Silva's circular shows the fluctuation in the average "spot" price of sugar for the last three years:

—	1903.	1904.	1905.
	s. d.	s. d.	s. d.
Java D.S., 15, f.l. terms	8 4	9 7¼	10 11¼
Pernams, 87° polarisation ..	6 10¾	8 1¼	9 2½
German beet, basis 88 per cent., Prompt, f.o.b., Hamburg ..	6 7½	8 2½	10 0
First marks granulated	8 1¾	9 9	11 9¼

It will probably need further statistics to prove whether the rise in price is due more to shortage of crops and more local consumption than to duties, but meanwhile it is interesting to note that the amount of sugar consumed in Continental countries has much increased.

Sugar Weights and Marks. On the London market, refined sugar contracts are made in the form laid down by the Refined Sugar Association. The contract embodies the conditions of the Association as to weight, delivery, and payment. The cwt. is taken as equivalent to 50¾ kilos, and bags, when used, must be new, and weigh not less than 850 grammes before filling. There are separate conditions for Dutch, French, German, Austrian, and Belgian sugars. French cube sugar comes in cwt. cases, and Dutch crushed sugar in barrels of about 2 cwt.

First Marks. *German Granulated Sugar.* These are, Bonart, C.F., C.R.M., D.V., E.C.H., F.M.S., G.D., Glauzig, Grœningen, Grasso, Hansa J.B.R., J.H., J.H.B.M., O.F., R.A.C.L., R.A.V., S.P.R., Star, Z.H., Z.A., Z.A.F., Z.R.B., Z.R.D., Z.R.M.

German Cubes. Hansa, C.Z.F., A.S.P., S.P.R., F.K.L., T.T.D., A.C.L., S.Z.G., Z.R.D., F.M.S., R.A.V., Meyer, X.L.R.

German Cut-loaf and Loaves. C.Z.F., A.C.L.

German Crystals. A.S.P., S.Z.G., E.A.R., A.Z., R.F., S.P.

German Castor Sugar. Skene, A.S.P., G.S., X.L.R.

French Granulated. Lebaudy, R.P., A.T.

French Cubes. Lebaudy, E.S., R.P., Say.

Dutch Cubes. A.S.R., S. & T., W.S.R.

Dutch Cut-loaf and Loaves. A.S.R.

Dutch Crushed Sugar. A.S.R., S. & T., W.S.R.

Dutch Crystals. W.S.R.

Belgian Cubes. R.T., R.B., Super.

Belgian Cut-loaf and Loaves. M.F.

Belgian Crushed Sugar. R.B. Super.

Austrian Cubes. C.Z.F., T.T.V., T.T.D.

Austrian Crushed Sugar. T.T.V., T.T.D., E.S.

SUGAR *concluded; followed by* CONDIMENTS

Group 24 PHYSICS 32	# THE STRUCTURE OF MATTER
Continued from page 4450	The Science of Crystallography. Its Value in Industry. The Molecular Structure of Metals. The Physics of the Stars. The Problem of Solution

By Dr. C. W. SALEEBY

Of the many new subjects to which reference has lately been made we must choose only those which are of wide interest, or, rather, those which we can already recognise as being of wide interest. The scope of our course will have been very wide, but the reader must not imagine that it has been possible for us to keep pace with what one of its most distinguished workers, Mr. Whetham, calls "the recent development of physical science." We cannot, for instance, discuss the newest work which has been done by Sir James Dewar and his followers in the liquefaction of gases, a process which has been successfully accomplished with every known gas, with the solitary exception of helium. Sir James Dewar, however, has lately been able to return to active work, and we may hope that he will at last conquer even this gas.

The Study of Crystals. We may briefly refer to another very important study which is also concerned with our conception of the three states of matter. This is the study of solidification and crystallisation. We can merely direct the reader's attention to the subject on three distinct grounds.

First, we must recognise that the study of crystals will help us to understand the molecular structure of matter. We must believe that the varying shapes of crystals depend, in some way, upon the varying shapes of the molecules of which they are composed. We conceive of molecules, of course, in terms of *stereo-chemistry*—that is to say, in terms of three-dimensional space. In our recent studies, both in physics and chemistry, we have seen how different kinds of crystals are able—ultimately in consequence of their molecular structure—to produce remarkable changes in a beam of light, and we have also noticed the extraordinary fact that there are certain forms of life which have a selective affinity for crystals, or, rather, for molecules of certain shapes, but do not act upon other molecules which are identical in every way but for the one difference which corresponds to the difference between the right hand and the left, or between any object and its mirror image.

The Crystalline Structure of Metals. Secondly, the study of crystals and crystalline structure is now seen to be of extraordinary practical importance; just as all trees have flowers, though the flowers are inconspicuous, so the metals, though we do not readily recognise it, have a crystalline structure. Further, we find that to this crystalline structure, to these mutual relations of the molecules, must be referred the gross physical properties of any specimen of a metal. The ultimate difference between the rod of steel, or the tube of steel, which remains intact and another which bursts on board a steamship and kills a dozen men with scalding steam is to be found in crystalline structure, in the relations which the molecules assumed when the steel, or other metal under consideration, underwent the process of solidification. It is interesting to note that the microscope, invented in the interests of biology, and long used by biologists alone, now forms an invaluable part of the *armamentarium* of the metallurgist, who is enabled by its means to make minute study of the crystalline forms of various specimens of various metals and alloys, and to correlate differences in this respect with physical properties, such as brittleness, elasticity, density and the like.

Value of Crystallography in Industry. If the reader should ask where he must look for the most noteworthy advances in this subject, and for the most extensive knowledge, he may be referred to the University of Sheffield, the metallurgical work of which affords an admirable instance of that wise tendency towards specialisation which the universities of this country are now exhibiting.

In this connection we may quote from Dr. A. E. H. Tutton, F.R.S. ("Times," June 20th, 1906). Speaking of crystallography, he says: "Its bearing on engineering, moreover, is of no trifling character, since the whole of the metallic materials employed by the engineer are crystalline substances. Hundreds of valuable lives have been sacrificed by the existence of flaws in metallic beams, girders, tie-rods, bolts, rails, wheels and axles, consequent on local development of crystalline structure, or on the local separation of crystals of a particular constituent in an alloy or a steel. Many of these might have been saved if we had possessed exact knowledge of the crystallographical character of metals, and of the influence upon it of the various metallurgical and mechanical processes to which steels are subject. Investigations to this end are at length being tardily initiated, and the practical utility of this branch of crystallography is so obvious as to appeal to all, and from motives equally economic and humanitarian."

"Neither Alive nor Dead." Thirdly, the study of crystals is of the most extraordinary interest in relation to the problems of life. In the narrow sense crystals are not alive; but they display certain characters which strongly suggest that, from some points of view, they may be regarded as intermediate between the living and what we are pleased to call non-living. M. von Schrön, the Director of the Pathological Institute of the University of

Naples, has been working for many years at this subject, and appears to have reached some amazing results. He believes that a crystal is an organised evolving being like an animal or a plant, and having its own biological laws. In rocks he discovers what he calls petro-cells (from the Greek word for a rock), and in these he recognises by the microscope a definite nucleus. He has taken thousands of photographs of what he believes to be crystal cells which are formed when a salt crystallises out of a solution, and he declares that the struggle for existence can be detected amongst such cells. In his view, all minerals are colonies of beings which live or have lived.

Does all Matter Respond to Stimulation? A very distinguished Indian physicist, Professor Chundra Bose, of the Presidency College, Calcutta, published in 1902 a remarkable book, entitled "Response in the Living and the Non-Living," in which he was enabled to show that various crystalline forms of matter exhibit response to electrical stimulation, and show fatigue and electrical phenomena identical with those which the physiologists have hitherto described as characteristic of living muscle. His work was met with the usual and necessary incredulity accorded to the pioneer, but his results have stood, and in the present year he has published another book, called "Plant Response," which carries his work still further, proving the identity of response to stimulation in the animal, in the plant, and in various kinds of crystalline inorganic matter. We may briefly quote from page 40 of Professor Bose's remarkable book, published in this country by Messrs. Longmans, Green & Co.:

"By following the electrical method of inquiry which has just been described, I have been able to prove that the power of responding to stimulus, and, under certain conditions, the arrest of this power, is the characteristic, not of organic matter only, but of all matter, both organic and inorganic; and that, in general, the various agencies which bring on the modification of response in one case—such as fatigue, temperature changes, stimulating or depressing chemical reagents—act in the same way in the other. The capability of responding, so long regarded as the peculiar characteristic of the organic, is also found in the inorganic, and seems to depend in all cases, both qualitatively and quantitatively, on the condition of molecular mobility."

All Elements have Crystalline Forms. We may conclude our brief review of this big subject by one or two more references to the work of Dr. Tutton, which is of extreme importance. He says:

"The fundamental fact of the science is that every solid chemical element, whether metallic or non-metallic, and every solid substance of definite chemical composition, be it naturally occurring or artificially prepared (with the exception of the few which have never yet been obtained in the crystalline condition owing to the great viscosity of their solutions or of their molecules when in the state of union), has its own definite crystalline form, which is just as much a characteristic feature of the substance, by which it can be identified, as is any one of its chemical or physical properties. This is a statement which it has only quite recently been possible to make with certainty. For it was for a long time thought that the members of the numerous well-known series of analogous chemical compounds (which only differ in containing a different member of a family group of chemical elements as their dominating and generally metallic constituent) were absolutely identical in their crystalline form, and they were consequently classed as 'isomorphous.' But the author of this article has been able to prove, as the result of fifteen years' work, that although the forms are very similar, and although they belong to the same type of symmetry, the angles between their corresponding faces are different, to the extent it may be of only a few minutes of arc, but in some cases by as much as a couple of degrees. Moreover, the amount of the difference is governed by a definite law, which connects the atomic weight of the metal or other dominating (acid-forming) element present with the whole of the properties of the crystals, whether of exterior form, of optical character, or of internal structure.

"The main result of the highest refinement of crystal measurement has been to establish the fact that perfectly developed crystals of the same chemical substance invariably exhibit faces inclined at precisely (to within one or two minutes of arc) the same angles, whatever may be the variations in the relative sizes of the different faces. In brief, the interfacial angles of crystals of the same substance are constant, and are the peculiar property of that substance, differentiating it from all others."

The Physics of the Stars. The term *astro-physics*, which has been popularised by the work of Miss Agnes Clerke, is equivalent to what is usually meant by the "new astronomy." It is obvious that the law of gravitation is a law of the physics of the stars; but this is not quite the meaning of the term astro-physics. It is practically astronomy as studied by the spectroscope, and depends upon the application of our knowledge of optics. Partly, as we have already seen, astro-physics deals with a purely physical problem, such as the effect of radiation pressure upon movements in the heavens, or the study of the motion of stars in the line of sight. But mainly, perhaps, astro-physics deals with chemical problems—only that they are solved not by chemical but by physical means. But we have discussed, in concluding the course on Chemistry, the chemistry of the stars and the manner in which physical means have enabled Sir Norman Lockyer and others, even before the demonstration of the transmutation of the elements on the earth, to declare that such transmutation takes place in the heavens. Here we merely ask the reader to obtain a definite idea of what is meant by astro-physics—a new astronomy of which the telescope is only a subordinate instrument, which entirely depends for its prosecution upon the employment of physical methods, of which by far the most important is the spectrum analysis of light.

The Problems of Solution. The moment we turn the mind to such a simple phenomenon as the melting of a lump of sugar in a cup of tea we realise that, commonplace though this be, it is profoundly interesting, and must surely be profoundly important. In the present outline discussion of it we shall follow Mr. Whetham, whose "Theory of Solution" (John Murray) is the most authoritative book upon the subject.

The problems of solution are important on every score. They have always been recognised as important for the physicist and the chemist, but we are only now beginning to recognise their extreme importance for the biologist and the physiologist. The reader has only to refer to such a book as "Recent Advances in Physiology and Bio-Chemistry" (by numerous authors; Arnold. 1906) to see that the greater our knowledge of the facts of solution in general the nearer we shall be towards understanding the facts of life in general and, notably, the facts of the relations between the infinitely complicated and numerous processes that are necessary for the life of the higher organisms. According to Mr. Whetham, "*the application of physical conceptions to the problem of living matter chiefly depends on the knowledge we possess of the physics and chemistry of ordinary solution.*"

It is of interest that the biologists were the pioneers in the modern elucidation of this subject, which began about a generation ago. The biologist Traube, followed by Pfeffer, showed how to construct what are called "semi-permeable membranes," which will permit water to pass through them, but will completely arrest certain substances that may be dissolved in the water. These membranes are in general made of porous unglazed earthenware, which has been impregnated with certain salts. The remarkable fact is that such semi-permeable membranes are found almost everywhere within the bodies of animals and plants, and play, as we now know, a most important part in their life.

The Laws of Osmotic Pressure. If we prepare a cell, the walls of which have this property, and fill it with a solution of sugar in water while we bathe its exterior in pure water, we find that this forces its way into the cell up to a certain point. This point can readily be measured if the cell has a glass tube containing mercury attached to it. Such a pressure gauge will indicate for us what is called the *osmotic pressure* of the solution after the maximum amount of water has forced its way into the cell from without.

This osmotic pressure follows certain laws, and these have been elucidated by the most distinguished student of physical chemistry now living, Professor Van't Hoff, of Berlin. We may quote the following two laws as stated by Mr. Whetham. The results obtained by Pfeffer show:

(1) That the osmotic pressure was inversely proportional to the volume in which a given mass of sugar was confined.

(2) That the absolute value of the pressure in the case of the solution of sugar was the same as that which would be exerted by an equal number of molecules in a gas when placed in a vessel with the same volume as the solution.

These laws are of extraordinary interest, for they must instantly recall to our minds two other laws with which we have long been familiar, and of which these new laws are verily no more than extensions. We already know the law of Boyle, that the volume of a gas is inversely proportional to its pressure. We now discover that this general proposition holds true not only of gases, but also of dilute solutions—evidently a splendid result.

Secondly, we know the law of Avogadro, which states that the pressure of a gas depends upon the number of molecules present and not upon their nature. We now discover that this law is true not only of gases but also of dilute solutions—an equally splendid result.

Several workers have shown by other arguments "that the osmotic pressure must be equal in amount to the gaseous pressure exerted by the same number of molecules when vapourised, and must conform to the laws which describe the temperature, pressure, and volume relations of gaseous matter." This holds good whatever may be our precise theory of the nature of the process of solution. It may be almost impossible to frame any clear idea of what actually happens when sugar melts in tea, and yet we are enabled to frame laws of solution which are absolutely identical with the corresponding laws of gases.

Mixtures and Compounds Again. How far do these laws help us to determine whether solution implies the formation of anything that can be called a chemical compound, or whether it means no more than a mixture? Elsewhere, of course, we have seen evidence to show (in the case, for instance, of the relation between water and alcohol) that some chemical action must be involved; and on the whole the present evidence is rather in favour of the view that solution is a chemical rather than a purely physical fact; in other words, that "a solution, say, of salt and water is in some way a chemical compound of these components; a compound in which the relative proportion between the components can vary continuously between certain wide limits."

It was soon discovered that there are certain noteworthy exceptions, as it would appear, to the usual law of the osmotic pressure. If we compare solutions of sugar and of alcohol, each containing the same number of molecules in the same volume, we find, as the law asserts, that they possess equal osmotic pressures; but if, instead of comparing sugar and alcohol, we compare sugar and salt, we find that, even though the two solutions contain equal numbers of molecules, the osmotic pressure of the salt, if the solutions be fairly dilute, may be almost twice as high as that of the sugar. It remained for another great physical chemist, Professor Arrhenius, of Stockholm, to show that it is not necessary, as Van't Hoff supposed, to regard this case as an inexplicable exception. On the contrary, we have only to suppose that the molecules of the salt

undergo a splitting up or dissociation, and we see that the abnormally high pressure may be explained. This dissociation is rendered much the more probable when we realise that these abnormal osmotic pressures are found in the case of solutions which conduct electricity.

What Happens to the Molecules. According to this theory, then, which is now well established, common salt does not exist as such when it occurs in dilute solution in water. The molecules have been dissociated, and exist as particles or atoms of sodium and chlorine, these being associated with electric charges. "Each salt molecule thus gives two pressure-producing particles in solution, and the double value of the osmotic pressure is explained. In stronger solutions this dissociation is not complete, and the osmotic pressure is less than twice the normal value."

This theory, then, shows us that Van't Hoff's laws are valid, even in the case of apparent exceptions to them. It recognises that these exceptions consist of solutions of *electrolytes* as distinguished from non-electrolytes, this new term being applied to substances capable of conducting an electric current, meanwhile undergoing change; and it explains abnormalities of pressure in terms of molecular dissociation.

An entirely different method of studying the facts lends further support to the dissociation theory. In this subject Faraday was again the pioneer. He showed that there was a constant proportion between the amount of electricity conveyed through an electrolyte and the amount of decomposition which that electrolyte suffered. This seemed strongly to suggest that when an electric current is conveyed through, for instance, a solution of sodium chloride in water what really happens is a dissociation of the molecules of the salt, the positively electrified atoms of sodium going with the current and the negatively electrified atoms of chlorine going against it. These "goers" Faraday termed "*ions*," a Greek term which has that meaning. The ion which moves with the stream, and towards the electrode which is called the cathode, is known as the *positive ion* or *cation*, while the ion which travels against the stream, and moves towards the electrode which is known as the anode, is called the *negative ion*, or *anion*.

The Movement of Ions. We have here, perhaps, the very first hint that electricity, and even an electric current, is particulate and atomic in structure. Said Von Helmholtz in his Faraday Lecture of 1881, years before the discovery of radio-activity: "If we accept the hypothesis that the elementary substances are composed of atoms, we cannot avoid concluding that electricity also is divided into definite elementary portions, which behave like atoms of electricity."

The next question which opened itself for study was plainly the character of the ionic movement. Since we measure the conductivity of a solution by the amount of electricity which it will convey in a given time under the action of a given electric force, and since the conduction of the current depends upon the movement of charged ions, the conductivity of the solution, which is a measurable thing, must depend upon the *number* and *velocity* of the ions. Now, the number is ascertainable, since we can ascertain the strength of the solution, and thus we are in a position to ascertain the speed at which the ions move.

Mr. Whetham himself is largely responsible for the means by which we are now able actually to see the ionic movement—not, that is to say, the movement of the individual ions, but their movement *en masse*. This can be done by means of an apparatus which permits us to place next one another solutions of two salts, one coloured and the other colourless. Says Mr. Whetham: "The solutions should be of the same molecular concentration, the same conductivity, and the denser solution must, of course, be placed below the lighter. Let us take as an example the case of solutions of potassium bichromate and potassium carbonate, which fulfil the necessary conditions. The colour is here due to the acid part of the salt, the bichromate ion, which has the chemical composition represented by Cr_2O_7; the potassium ion is colourless. When a current of electricity is passed across the junction between the liquids the colour boundary is seen to move, and, from the rate at which it creeps along the tube, the velocity of the bichromate ion under a given electric force can be determined."

The Speed of Ions. The reader will almost certainly imagine that the speed with which the ions move will be very great, but it is really remarkably small. Much the fastest moving ion known is hydrogen, but when the electromotive force is one volt per centimetre, the hydrogen ion moves only at the rate of 4 in. per hour, and this is about ten times as fast as the speed of most other ions. We must distinguish this movement, of course, from the movement of the electric current—or, rather, we must distinguish the two speeds. The movement of the current is almost as rapid as that of an electric wave—that is to say, is almost equal to the velocity of light. Mr. Whetham compares the two movements with the case of the movement of a stick. If you push one end of the stick, the whole of it moves on. Its velocity may be as slow as that of a hydrogen ion—a mere 4 in. per hour. But something else moves with an immeasurably greater rapidity, and that is the wave of compression, which is induced by the push, and which must travel along the whole length of the rod before its advancing end can move. "The slow movement of the rod as a whole, when once started, corresponds with the slow drift of the ions; the almost instantaneous passage of the wave of compression along the rod corresponds with the velocity of electricity in the electrolytic solution."

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DRESS
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MILLINERY

Essential Qualifications of a Good Milliner. The Apprentice. Importance of Suiting a Customer's Style. Stitches and Accessories

By ANTOINETTE MEELBOOM

MILLINERY is essentially a woman's profession, but to be successful she must have a light and delicate touch, accuracy and neatness, good taste in blending colours, a correct eye, judgment in adapting the style to the wearer, and a liking for working with dainty and pretty materials. Few tools are needed.

There are two seasons in the millinery trade, spring and autumn, with six to eight slack weeks in the summer and winter—July and August, and December and January.

The Apprentice. A girl of about 16, wishing to become a milliner, is usually apprenticed. The period is two years, in the second of which she receives about half-a-crown a week pocket-money. In some houses a premium is asked; others take girls without a premium, but through introduction. The girl is taken on approbation for some weeks to see if she has the necessary qualifications. At the end of the two years, if she has given satisfaction, she is usually taken on as improver, with a weekly salary starting generally at about 15s. a week. In the slack time some houses work their apprentices half time, or give them a holiday till the next season opens.

The head assistants and head milliners are engaged by the year, with salaries varying between two and five guineas a week.

It is well for a girl to be apprenticed to a small business, although it should be a first-class one, as she will then have a good opportunity of seeing all kinds of work done. In the larger houses the work is divided up into different branches, one room being set aside for making hats, another for toques and bonnets, and so on. An apprentice will never regret the time spent in matching—that is, obtaining from the warehouses patterns of silks, velvets, ribbons, etc., which tone exactly with a particular pattern. Until one has tried, it is difficult to realise how difficult some colours are to blend.

Advising a Customer. A milliner who thoroughly understands her work is able to advise her customers which of the many prevailing styles suits her, and a good business woman is sure to be a success.

Though the fashions change so rapidly many of the principles never change, and, when mastered, the worker will find herself able to adapt them to prevailing fashions.

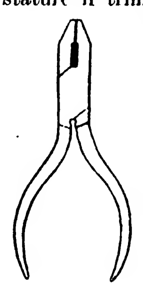
The importance of wearing what is really becoming without considering whether it is the latest fashion or not cannot be over-estimated. A clever milliner's aim is to adapt the prevailing fashions to suit the face.

Modern styles are so elastic that it is perfectly easy to be well dressed. No rules on how to dress can be laid down, but an important point to remember is that in choosing a hat or toque it is not only well to decide with what costume it will be worn, but, if possible, to try it on when wearing the dress. It will avoid possible disappointment, as that which looks well and in perfect style with a tailor-made costume may look small and insignificant when worn with an elaborately trimmed dress or big furs.

Hair-dressing and Millinery. The way in which the hair is dressed is another consideration in the choosing of headgear. The most fashionable headgear is modelled on the way the hair is dressed at the moment; thus, if the hair is worn low down at the neck, the brims will be long at the back. When the hair is worn at the top of the head, a short brim at the back with high crown, or a low crown and bandeau, looks best. For hair worn rolled back from the face, a turned up brim in front is most suitable.

Thin faces should have the hair dressed loosely over the temples, and a soft-looking edge to hat or full front to a bonnet. When no fringe is worn and the hair brushed smoothly back, a bonnet with rucked edge, or a brimmed hat, will be the best style to adopt. Hair dressed in coils and plaits at the back usually requires a large headline. Coils and plaits round the front require the headline cut rather wide there.

Large picture hats look well on tall people, though they may be worn by persons of small stature if trimmed very lightly. A hat should *never* be over trimmed.



1. WIRE NIPPERS

A full face needs a broad trimmed hat.

A long face looks best in a brimmed hat, trimmed broad and worn over the face. High trimmings, which lengthen the face, should be avoided. Broad toques, fitting well on the head, may be worn.

The most becoming hat for a round face is a round hat with an equal brim all round, except at the back, and worn tilted slightly off the face in the front. No very small hats or toques are becoming to this style of face.

Drooping brims of the flop and mushroom type are not becoming to people past their youth, as they cast a shadow on the face. They are best suited to young, round faces.

Brims turned up in front can be worn by small round and oval faces.

Let your customer wear the colours that suit her. Do not advise her to wear a colour that

does not match her complexion, hair and eyes, no matter how fashionable.

The blonde may wear delicate shades of blue, pink, and green.

The brunette looks well in deeper and richer colours.

The choice of shades depends greatly on the complexion, as the colour may suit the hair but not the skin.

White is very becoming to fresh and rosy skins, but should be avoided by those with pale and sallow complexions.

Black is not becoming to pale and sallow complexions, unless combined with lace and a colour in the trimming. It looks well on fair people with a little colour in the face.

Requisites. We must now consider a milliner's "tools."

Gum or Gum Labels.

Tissue Paper.

Bowl and Damping Rags. For steaming and pressing.

Notebook and Pencil. For writing down measurements.

French "Doll's Head." Used for cap-stand.

Block for Shaping Crowns.

Kilting Machine.

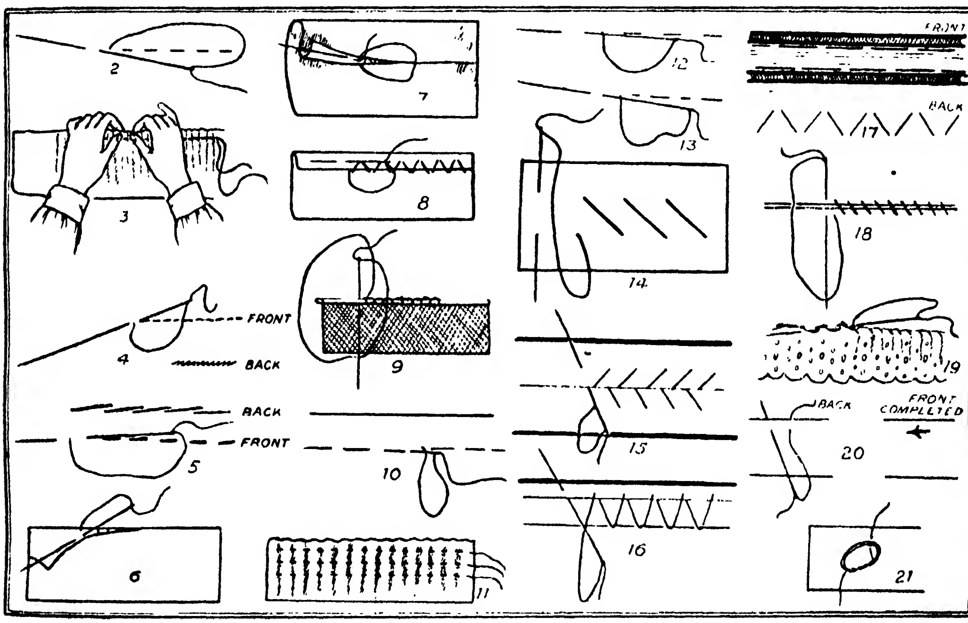
Accordion Pleating Machine.

Pinking Machine.

Velvet Brush.

Stitches. The following are the stitches used in millinery:

Running. Pass the needle and cotton in and out of the material at equal distances. The stitch appears the same on both sides. Used



2. Running 3. Fly running 4. Back stitching 5. Long back stitching 6. Slip stitching 7. Slip hemming 8. Velvet hemming 9. Wire stitching 10. Gathering 11. Shirring 12. Tacking 13. Tacking for crape 14. Basting 15. Lacing stitch 16. Catch stitch 17. Straight bandeau 18. Oversewing 19. Whipping 20. Tie stitch 21. Stab stitch

Millinery Wire Nippers. Price 1s. to 2s. 6d.; the latter are made of English steel. They must be light, small, and with broad noses [1].

Needles. Packet of straw needles, mixed, sizes, 5, 6, 8. Price 1d. No. 5 for wiring, and No. 8 for hemming.

Steel Pins. For pinning silk, velvet, etc.

Lillikins. For pinning velvet edges, joining laces, etc.

Thimble.

Scissors. About 7 in. long, with sharp points.

Tape Measure. Dean's are the best.

Sewing Cotton. Fine and coarse, white and black, No. 10 for sewing on trimmings.

Sewing Machine.

Flat Irons. No. 2 and No. 8, for pressing straw and steaming velvet, etc.

Ironing Blanket. For pressing.

Pocket-knife. For ripping fur.

for making the hem of head-linings, and joining two parts together where no great strength is needed [2].

Fly-running. Place the needle in the material and hold it lightly, close to the point, with the right thumb and forefinger. The thimble should propel the needle. The left hand holds taut the material, which is pushed on the needle by the left thumb and forefinger. As the needle fills with material, push it off from the eye end. The needle is not drawn through until the whole length is gathered. For long lengths, thread the needle from the reel of cotton or silk, which will prevent it knotting [3]. It is a rapid way of running, and is used for all branches of millinery that require gathering, such as tuckings, casings for silk hats and bonnets, tuck running in chiffon, tulle, etc.

Back Stitch. Insert the needle exactly where the last stitch was begun, and bring it out in front the same length of the stitch just made. To obtain a regular row of stitches, each stitch must exactly meet the last, and be of the same size [4]. Used for joining two pieces of velvet, silk, or cloth, wherever the material is likely to be stretched and requires strength.

Long Back Stitch. Instead of inserting the needle in exactly the place where the last stitch left off, as in back stitching, take a short stitch back, which in straw-working will be slanting in the direction the straw is plaited [5]. Used in straw-working; for sewing in head-linings, bandeaux, mulling; in shape-making, joining side band to head-line of brim shape; in covering, sewing upper and under covering of brim to head-line, also material tip to that of shape.

Slip Stitch. Take one stitch on the turning of one piece of material, and the next exactly opposite on the turning of the other piece [6]. Used for joining the upper and under edges of hat brims covered in velvet, cloth, or silk, and wherever invisible joining is required; stitching on rouleau to covered or felt hats, etc.

Slip Hemming. Use a fine needle and cotton, or silk to match material, and take up one thread of the material under the fold. Slip the needle into the fold and make a short stitch as in running; draw the needle out, and just take one thread again of the material under the fold. Do not pull the stitches tight; they should not show on the right side [7]. Used for invisibly hemming velvet, silk, crape, etc,

Velvet Hemming. Turn down the raw edge of material once; take a stitch as in running through the fold, and take one thread of the material under the fold in a slanting direction. Work from right to left with fine needle and cotton [8]. Used for neatening cut edges of velvet, and where it does not require a roll hem.

Wire Stitch. Hold the wire firmly in place, stab the needle in the hat *above* the wire, holding back a loop of cotton under the thumb. Stab the needle back again *under* the wire, bringing it through the loop from behind and pull tight. Work from right to left. The stitches must just fit the wire [9]. Used for all parts requiring to be wired.

Gathering. Take up half as much on the needle as has been passed over [10]. Used when a long length has to be gathered into a small space.

Shirring. Rows of fine gathering placed underneath one another. The stitches must exactly correspond with the row above, and the cottons are drawn up together [11]. This stitch is used for fancy linings for brims, for children's millinery, etc.

Tacking. A large running stitch [12]. Used for keeping two parts temporarily together.

Tacking for Crape. A long and small running stitch [13]. Crape being a springy material, this stitch keeps it better in position than ordinary tacking.

Basting. A long and a short stitch, the first taken slantways, the second perpendicular [14]. Used for holding together temporarily the material and lining previous to being tacked.

Lacing Stitch. Place the needle under the fold, bring out in a slanting direction. Place the needle in again on opposite side, also in a slanting direction [15]. Used for securing the raw edges of velvet folds. It is sometimes called Milliner's Herringbone, but is always worked from right to left.

Catch Stitch. Take the needle under the turning and bring out to right side. Pass under the wire, then over the wire, and under the turning again, and repeat [16]. Used for fastening down the upper side of material brim to the second edge wire of under brim.

Round Bandeau Stitch. The stitches are taken close to the edges of the ribbon wire to prevent curling up. Make a long stitch of ¾ in. on upper edge of ribbon wire. Bring thread to bottom edge of wire at the back, take the needle through at nearly half the length of the upper stitch already made. Then take another ¾ in. stitch, and so on. On the reverse side a series of /\ /\ will be seen. Use black cotton on white net and wire, and vice versâ [17]. Used for sewing ribbon wire to net for foundation of round and straight bandeaux.

Oversewing. Place needle pointing straight towards you in the raw edge, hold the work round first finger of left hand. Repeat this, forming a slanting stitch from right to left on the right side, and a straight one between each [18]. Used for joining lace, sewing fur, neatening the raw edges of velvet for straight bandeau where a turning will make it too clumsy and thick.

Whipping. The needle is taken over the raw edge of the material, put in from back to front, and over the edge again. The stitches are taken fairly long, and the needle, as for "fly-running," is not taken out until the finish [19]. Used instead of gathering, to prevent ravelling in lace or tulle.

Tie Stitch. Stab the needle through from the right side; leave an end of cotton, bring back the needle from the back, and tie a knot [20]. Used for securing light trimmings, trails of flowers, lace, tips of feathers, loops of ribbon on a brim; fastening head-linings in position inside bonnets and hats.

Stab Stitch. Proceed as with the tie stitch, but take the needle through and through the hat for extra strength [21]. Used for sewing on trimmings that require strength.

Continued

FIFE. PICCOLO. FLUTE. OCARINA

Construction and Peculiarities of the Instruments. Attitude of Player. Fingerboard. Scales. Positions. Effects. Exercises

Continued from page 4488

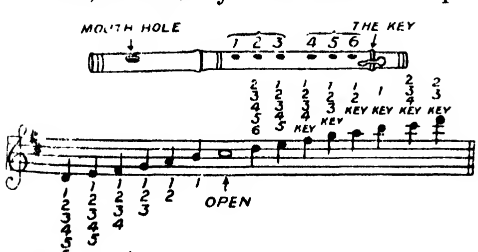
By ALGERNON ROSE

FIFE

The fife, unlike the flageolet whistle, is provided with a single key. The instrument has a compass of two octaves, from D on the fourth line treble clef.

The instrument should be held horizontally. Keep the head and body upright, and rest the instrument on the middle joint of the first left finger. Place the thumb just below the first hole. Put the right thumb opposite the fourth hole, against the side of the fife, and not underneath it. This will permit the little finger to remain over the D♯ (or E♭) key. Following these directions, keep the first and second left fingers carefully curved, and the third nearly straight. Round, also, the first and second right fingers. Except when used for the key, or keys, the two little fingers do not rest upon the fife. They must never hang beneath it. Do not hold the fife tightly in the right hand, nor press the fingers forcibly on the holes, as this will impair neat execution. Avoid raising the fingers more than half an inch above the holes. Aim at delicate surface-playing rather than force of finger attack.

Blowing. Close the lips, and compress them a little. Holding the instrument as described, place the mouth-hole against the middle of the underlip. Make sure that the upper lip comes within the radius of the aperture. Relaxing the upper, press the fife against the lower lip. Blow into the instrument with moderate force. Take care that the air passes into the mouth-hole and not over it. If it does, there will be a hissing sound and waste of effort. While blowing, endeavour to pronounce the syllable "too." With practice, a clear steady sound will be produced. Do not close, at first, any of the holes. The open



sound of the tube is C♯, third space, treble clef. To get B, a tone below, put down the first left finger, and blow "too," as before. For the A below, add the second finger. To get the G, add the third. For the F♯, cover the fourth hole, and so on, as for the flageolet. The annexed diagram of the fife, with the holes numbered, and the staff showing the scale from D to D of two octaves, indicates the manner of fingering for the production of different tones.

Exercises. Simple as this scale may appear to be, there is a great deal to be learnt from it by diligent study; but the only way by which progress can be made is through regular daily practice. The first thing for the beginner to understand is the relative value of Time, or duration of sound, and Pitch, or variety in sound. Starting at the lowest note, D, blow into the instrument steadily and clearly, counting mentally four, regulating the beats by the ticking of a clock or a metronome. Having done this softly, repeat the sounds with more force during the first and second beats, articulating the same note sharply twice on the three and four. In the same manner, next try the E above the D, the F♯ above the E, the G, and so on up the scale, blowing with increased pressure ascending, and gradually softer descending. After getting facility on each note of the compass, as regards time, or speed in playing, proceed to the next department of study.

Intervals. An interval is the distance between any two sounds, and the facility in which musical tone is made to pass from one interval to another gives the charm to what is known as melody. Now try to get accustomed to the simplest intervals, known as seconds. Play the low D, counting two. Without break, pass to the E above for the three and four. Repeat the E on two beats, making the F♯ follow on the next two. In this way go up, step by step, to the highest notes, descending the ladder of sound in the same fashion. Next try thirds. Sound the lowest D, counting two as before. Skip the next note, but, without break, play the F♯ on the three and four, F♯ being a major third above D. Sound the E, passing over the next note and following with G. Play the F♯, skipping the G and blowing A. Thus, in thirds, practise slowly and carefully up and down the scale.

Proceed to fourths. Sound the low D as before, then skip two notes, and blow the G easily and without pause between one sound and the other. Blow the E, and follow it by A, a fourth above the F♯, succeeding it by B, G, and C♯, and so forth up and down the instrument. Next try fifths. These may sound ugly, but no matter. Check the intervals on a piano at first. Returning to the low D, skip three notes, and blow the A above. Count two beats on the first sound, and complete the three-four on the second. In the same way follow the E by the B above, F♯ by C♯, G by D, thus going up the compass by fifths, and going down in like manner. Try sixths.

Sound the low D. Now skip four notes, and, without interruption, pass to the B above. The student should write these exercises out on music paper. Sound the E, linking it with the C♯ above. Play the F♯, following it by the D. Thus, in sixths, go up and down the compass. In the same way try sevenths. Follow the low D by the C♯ above it, always blowing in strict time, and endeavouring to avoid any hissing sound with the upper lip. Blow the E with the D above, the F♯ with the E above, and so up and down the compass.

Finally, take the octaves. After blowing the low D get the second note at the higher pitch, with the same fingering but increased pressure of breath. In the same way blow the low E with its octave above. As before, get the F♯. But now, to facilitate the sounding of the octave above, with the little right finger put down the key, and, in like manner, use this key for the octave notes of G, A, and B. After playing the C♯ with all the holes open, to get the octave put down the second and third left fingers, the first right finger, and the key. To get the top B, close the second and third holes only, using the key. Descend in octaves in the same way. The student should now find little difficulty in executing the march tune of the Guards, given at the head of this page.

PICCOLO

The piccolo is an octave higher in pitch than the ordinary flute. It is called "E♭," although the lowest note really sounds D♭. As the embouchure is small and the holes are rather close together, this instrument is a good one for a boy to take up, as it is more suited to his lips and fingers than the big concert flute. Besides, it is less than half the weight of the latter, so that it is much more portable. On account of the shrillness or brilliancy of its tone, one piccolo suffices in a military band of brass and reed instruments consisting of as many as sixty-two players.

In the score, the piccolo is always written for an octave lower than the notes which are actually played, and the part is invariably noted in the G, or treble clef. The compass of the piccolo is from D, first space below staff, to D above, fourth ledger line, and the instrument gives all the intervening chromatic notes. The cost of a good piccolo ranges from 15s. to £15 15s., according to whether it is of cocuswood or ebonite, or has from four to ten keys in brass, German silver, or silver. The lowest octave being weak and of little value, the student should particularly practise that part of the compass which begins at D, fourth line treble clef, and goes up to F♯, two octaves above. This gives a range of notes which possesses remarkably effective qualities, used in a beautiful way by Beethoven in the "Pastoral" Symphony, or Berlioz in "Faust."

The instructions given for the fife and flute apply also to the piccolo. But, although this instrument lacks the nobility of tone of the big flute, the student should note that it excels in

Ex. 1.

certain trills and florid passages, one of its most charming characteristics being the rapidity in which reiterated notes can be articulated by double and triple tonguing.

We give here an example of *double-tonguing*. Tongue the first note, and blow the second very strongly from the throat. Do not hurry at

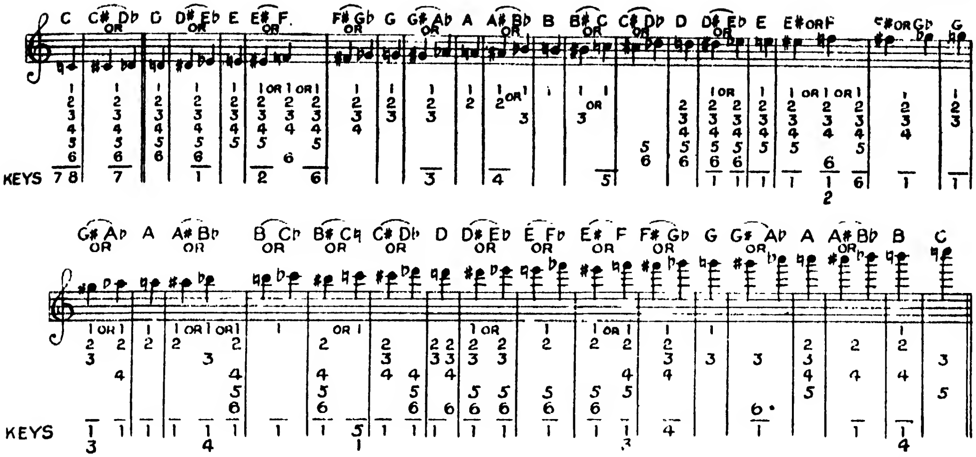
Ex. 2.

first. With practice, the player should be able to imitate in velocity and neatness of execution the roll of a side drum. [Ex. 1.]

In triple-tonguing, tongue the first and second notes, and blow the third. [Ex. 2.] This sort of thing when properly done is well worth hearing in solo work. At the same time, the student should practise daily chain-trills, going from note to note in the different major scales, because the piccolo is frequently employed to imitate bird-like effects. Those trills which are most difficult of execution should, of course, be given special attention. For example, practise those on the lowest D♯, with the E♯ above; the E♭ with the F above; F♯ with the G♯ above; A♭ with the B♭ above; C♯ with the D♯ above; C♯ with the D♯ above; and the A♭ on the first ledger line with the B♭ above.

FLUTE

The flute is one of the most important instruments in the modern orchestra. The flageolet and the church organ pipe exemplify one great division of the flute family, known as the *flute-à-bec*. The other great division, with which we are now treating, comprises all the different kinds of *flauti-traversi*, or horizontal instruments. The reason why to-day, in the most advanced orchestral music, the flute plays such an important part is owing to the acoustical discoveries of Captain Gordon, made practical through the



system of manufacture known as the Boehm. Before such improvements the flute, in many respects, was defective in intonation and difficult to finger. As it may not be within the means of every student to purchase an instrument with the latest system of fingering, he will probably have to content himself with an ordinary military instrument.

One to Eight-Keyed Flutes. The *one-keyed* flute, described under Fife, has a D♯ lever pressed down by the little finger of the right hand. The *four-keyed* flute has a second, or E♯ lever, worked by the third right finger; a third, or G♯ lever, worked by the fourth left finger; and a fourth, or A♯ lever, worked by the left thumb. The *six-keyed* flute introduces a fifth lever (C♯), and a sixth (or C♮), both worked by the fourth right finger.

Coming to the *eight-keyed* flute, we have an additional seventh lever, or C♮ shake-key, worked by the first right finger, and an eighth lever, or E♯ key, played by the fourth left finger. Familiarity with the different keys is easily acquired if the student who begins with the fife has an opportunity of learning afterwards the flutes with four, six, and, finally, eight keys. A well-made instrument of this class, guaranteed for six years, can be obtained new for £3, or for considerably less second-hand.

Military Scores. In a military score the piccolo comes at the top. Beneath it is the F flute. Beneath that, again, is the E♭ flute. The actual pitch of the E♭ and F flutes respectively is D♭ and E♭. In most bands, as they are seldom wanted together, one man plays both instruments. Should they be needed simultaneously, the piccolo player takes the second instrument. The tone-quality of the F flute is lighter than the E♭, the latter being richer and fuller. Although regulation flutes used in the drum-and-fife bands have but one to four keys, those employed with the brass and reed instruments require the eight mentioned. It is only possible here to give the chromatic scale of the last-named instrument, which will be easily understood by the diagram at the head of this page.

Concert flutes, on the other hand, have ten, eleven, or twelve keys, besides rings. Most players master the eight-keyed fingering before proceeding to the instrument with cylindrical bore and larger holes adopted by Boehm. Amongst the many methods for the latter may be mentioned those by Bousquet and Taffenel (Paris), and Svendsen and Pratten (London). As regards pitch, the tuning-slide enables the instrument to be flattened but not sharpened when closed; but all wind instruments get sharper as they become warmer through the breath of the player or the heat of a concert-room. Before playing, therefore, warm the instrument well with the breath through the mouth-hole.

OCARINA

The ocarina is of terra cotta, resembling in shape the body of a little goose, the Italian word "oca" implying that bird. Because the large interval cavity has no outlet, or bell, the musical quality of the tone is of acoustical interest. There is a peculiar hollowness in its character, somewhat like that of a stopped organ pipe.

Compass and Construction. The compass of the solo ocarina comprises a chromatic scale of 20 distinct semitones extending, in the C instrument, half a tone below middle C to F on the top line, treble clef. Made of larger sizes, at different pitches, the compass is extended downwards by increasing the cavity. Effective combinations of six players have made monetary harvests, especially on the Continent. The tone is sweet and pure. Although incapable of great force, it has a remarkable carrying quality. The mouthpiece is where the head of the goose should be, and the tuning-slide is situated in the region of the creature's breast.

Pull out the slide to lower the tone. Push it in to raise it. The body of the bird is pierced by ten holes, five for each hand. Place the mouthpiece to the lips. Two holes only should then be at the back; cover these with the thumbs. Place the first finger of the right hand over the hole at the bird's tail. Put the second, third and fourth fingers over the three holes which follow in the direction of the mouthpiece. Close, with the first finger of the left hand, the

hole nearest the tuning-slide, and, with the second, third and fourth fingers, those which are in line with the first.

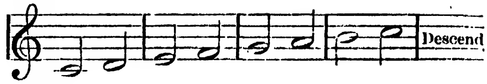
All the holes should now be covered, not with the tip but with the ball of each finger, so as to prevent any escape of air and a bad effect. Put the mouthpiece, not into the mouth, but between the lips. Blow lightly into the instrument. Breathe through the nose. Endeavour to get the tone even; never force it. The note sounded will be C on first ledger line below staff. Check this with a piano.

C Major. After sounding middle C, raise the first right finger, covering the hole by the bird's tail. Blow as before, softly. This should give D, a tone above the C. Lift the second right finger. The result will be E. Raise the third finger. This will sound F. Withdraw the fourth finger. The result will be G. To get the A above, raise the third finger of the left hand. This may require practice, as the third is the weakest digit. But the other notes of the left hand must be kept firmly closed. To get the B above, lift the second finger. Raise the first for the C. Take away the left thumb for the D, and the fourth left finger for the E. With all the holes open, sound F. Descend the scale in the same way [Ex. 1].

Tone Production. Sustained and gliding effects are accomplished by steady blowing in the way described, and the endeavour should be to make the sounds of the scale travel as smoothly as possible from one to another. Staccato is the reverse of this. The way to do it is, on producing each sound, to articulate the syllable "too," by giving to the tongue the same action as is done in spitting a bit of fluff out of the mouth. This tone-stroke emphasises the initial vibration, and quick withdrawal of the member allows the necessary air to pass into the instrument [Ex. 2]. Having obtained facility in playing the scale staccato, make a triplet of each note, so that it is heard three times distinctly before the next is played. This is done by pronouncing, mentally, "too-tle-too" for each note [Ex. 3]. After this, endeavour gradually to increase the speed with the first method of blowing. Until the student becomes familiar with the fingering, this will require daily practice. He should not be satisfied until he is able to run up the scale with one breath, and down again with the next [Ex. 4]. Then take practice in intervals. The Violin course will suggest appropriate exercises [page 2121]. Expression is added, when sustaining a note in a melody, by the use of the vibrato. This is done by fluttering the breath in the mouth rather than in the throat, as in singing.

Chromatic Scale. The fact that the ocarina can be played chromatically gives it a legitimate musical value. Sound the C, as before. To get C♯, the same fingering may be used by blowing harder. A more artistic way is partly to uncover the hole stopped by the first right finger. Taking off the first finger entirely, sound the D. To get D♯, replace the

Ex. 1.



Ex. 2.

Ex. 3.

Ex. 4.

Ex. 5.

first finger, leaving the second hole open. Sound the E and F as before, by uncovering the first and second, and then the first, second and third holes.

To get the F♯, close the third hole but uncover the fourth. Sound the G, as before, by opening the four holes, and the G♯ by stopping the third hole and uncovering the fourth and fifth, the latter by the third left finger. Sound the A by opening the five holes, but replace the third finger of the right hand and take off the second finger of the left for the A♯. For the B, remove the third finger, leaving the six holes uncovered. Sound the C, as before with the seven holes open. For the C♯, take off the left thumb, but put down the third right finger. For the D, remove the third finger. For the D♯, take off the fourth left finger and put down the third of the right hand. For the E, displace the third finger. For the E♯, as for the F, all the notes are open. But the note is "humoured" by the breath [Ex. 5]. Descend in the same way.

Having returned to the C, if the instrument is blown very softly, with all the holes closed, the semitone below the pitch-note, B, will result. Therefore, it will be perceived that what is called "humouring" the breath greatly affects the intonation. The student must know what tone he desires to produce. His ear will then enable him to get it.

The Trill. An excellent way of getting accustomed to the fingering of the chromatic scale is to practise trills a semitone apart. Begin slowly, and play softly, gradually increasing the speed. After regular daily practice, the knack will be acquired of ascending and descending the scale in this way without break either in intensity of tone or regularity in rhythm.

Fife, Piccolo, Flute, and Ocarina concluded

DETAILS OF CHEESEMAKING

The Cheddar Process. Scalding, Grinding, and Pressing. Cheshire, Blue-veined, Stilton, Gruyere, and Soft Cheeses. Best Dairying Books

continued from page 4492

By Professor JAMES LONG

The Cheddar Process. All things considered, Cheddar is the most popular cheese in the world. The best is produced in Somerset, Ayrshire, and Wigtownshire. It is the staple cheese of Canada and the United States, as well as of the Australian Colonies, and there is no other variety which approaches it as a pressed cheese from the point of view of combined texture and flavour. The system of production may be regarded as a type, and the most perfect type, of that adopted in the manufacture of pressed cheeses of other varieties, to which, therefore, we need but briefly refer.

The milk supplied by the cows in the evening is strained and poured into the cheese vat, and stirred until sufficiently cool to prevent the too liberal rising of the cream, which ascends with greatest rapidity in warm milk. On the following morning the cream which has risen is removed by skimming and mixed with a portion of the milk in the vat. In some cases this mixture is poured into a smaller vat and heated to such a temperature as will raise the remaining milk of the evening with that of the morning, when the latter has been added, to the required temperature for coagulation. The morning's milk is strained and poured warm into the vat already mentioned, and if the vat has a double lining or jacket, so that the milk can be heated by hot water or steam, the second vat becomes unnecessary, as the whole volume is then raised to the required temperature at once. Where two vats are employed, this temperature may be reached with accuracy by the aid of the following formula from "Elements of Dairy Farming," by James Long.

Method of Raising the Temperature of Milk. "Multiply the number of gallons in the tub by the number of degrees which it has to be raised or lowered, and divide the number so obtained by the gallons of milk in the warmer. The result shows the number of degrees above or below 84° F., to which the milk in the warmer must be brought. Thus, if we have 45 gallons in the large vat, and 15 gallons in the small one at 80° F, and we desire to heat the whole to 85° F.,

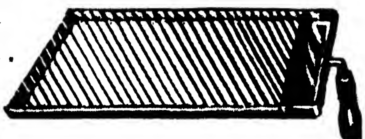
35. POND'S CURD BREAKER

we must raise the smaller quantity through 300° F. of heat (45 + 15 × 5), thus:

$$300 \div 15 = 20° \text{ F.}$$

"If we add the result (20° F.) to the desired temperature (80° F.), we get 100° F. as the temperature to which it would be necessary to heat the 15 gallons. It is, however, undesirable to heat milk much above 90° F., and we consequently make a fresh calculation, with the result that we find it will be necessary to heat half the milk to 90° F. to bring the whole volume to 85° F."

Care must be taken that too much heat has not been lost before the temperature is artificially raised. The required temperature being reached, the milk is stirred, the requisite quantity of sour whey—if this be employed—is then added at the same temperature, and all is ready for the addition of the rennet. The quantity of whey should be regulated in proportion to the acid it contains—and here again a test for acidity becomes necessary. If the evening's milk has not fallen below 70° F., although in some cases 68° F. may be safe, sour whey may not be needed. The milk for renneting is heated to different temperatures in accordance with the practice or custom of the district or of the individual maker. In Scotland, 84° F. is largely employed; in the West of England, from 85° F. in autumn to 90° F. in spring; but the maker, who should invariably be a trained hand, will in most cases adopt that temperature to which he has been accustomed, although he may see occasion to modify it where conditions change or are new. Coagulation is complete in from 40 to 50 minutes. In the United States, however, the curd is brought much more quickly, but the cheese is less fine in quality and keeps less perfectly, for the smaller the quantity of rennet used the better the keeping properties of the cheese.



34. POND'S CURD KNIFE

Cutting the Curd. Coagulation being perfect, the curd is cut, either with the knives commonly employed in the dairy, with the American knives already referred to, or with the oblique bladed knives made by Pond [34]. The curd should be cut evenly throughout, that each piece may be of similar size. After cutting, the vat may be covered and left for a short time, but stirring and breaking is usually begun within the hour. During this operation large pieces of curd will be broken smaller, but the work must be very gentle, that the curd may not be damaged and the fat it contains lost [35]. Stirring lasts from 15 to 30 minutes, when the work ceases for a time—the vat being again covered—to be followed by the scalding process, during which acid rapidly develops, while the tender curd

becomes firm, and at first comparatively tough. Stirring continues during the process of heating, whether a portion of the whey has been removed or heated separately and subsequently returned to the vat, or whether the whole mass be heated together through the medium of the jacket. In Ayrshire makers scald to 98° F., sometimes to 102° F., while in Somerset, scalding point varies from 90° F. to 94° F., many American makers employing a still higher figure—sometimes as much as 104° F. On many farms there is a second scalding, the curd having been allowed to settle for a few minutes after the first. In this case the scald varies from 94° F. to 98° F., which is reached at the end of the season; but in all cases it should be remembered that the temperature to be adopted depends upon the acidity of the milk at the time of renneting, and the employment or not of sour whey. Stirring is again resorted to in order to help the curd to acquire condition—and this needs both skill and judgment on the part of the maker. If the acid in the milk be one degree more than was present before the rennet was added, that condition has generally been reached. The object is to obtain an elastic curd, in which there is practically no toughness. The curd, indeed, should string out when attached to a hot iron gradually drawn away by the hand.

After stirring, the curd settles at the bottom of the vat, and here it remains for a time, the whey being drawn off, passing through a strainer on its way; but it is important that it should not be drawn unless the time is opportune. If it remain too long there may be too much acid; if too short a time an insufficient proportion. It should be pointed out that where sour whey is not employed, not only is the evening's milk maintained at 68° F. to 70° F. until the morning, but that the second scald may sometimes need a temperature of 104° F. to 106° F.

Scalding. In the scalding process the temperature of the curds and whey should be raised slowly, otherwise the curd may be toughened, and the whey then prevented from escaping sufficiently for the maker's purpose. The whey having left the vat, the curd remaining at the bottom in the form of a mat is cut and piled in cubes about 6 in. square. These cubes are from time to time changed in position, that each may be properly aerated, but they are still kept together in a mass that heat may not escape, for that is still essential—so much so that the mass should be covered with a cloth, which may be doubled if acidity need extra promotion. Indeed, the vat itself may be covered with its lid if circumstances demand it. The curd is then left until it is sufficiently acid—a condition which the maker must determine for himself. It is then broken up into small pieces, tied in a cloth or cloths, and, under some systems, slightly pressed either in the bottom of the vat, the rack being placed beneath it, or in a curd cooler, which many cheesemakers use. Where there is no pressure employed, the curd is usually again cut into cubes, the pieces turned or changed in position, and still left to drain, this process being repeated if it be found necessary. During the whole of this work, however, the temperature of the curd should be maintained at as near 90° F. as possible until it be sufficiently ripe or mature for grinding in the curd mill.

It is almost needless to say that the process thus briefly described is one which permits of variations in practice, for there is no method which is really empirical, so long as the desired result is achieved in reasonable time—and it is important that the process should not take too long, for cheesemaking is at the best an industry which demands considerable attention and some anxiety from day to day. A mellow cheese of fine flavour cannot be produced unless sufficient acidity has been developed in the curd. If the whey contain 1 per cent. of acid when the curd is believed to be ready for grinding, good results may be anticipated; but the maker may be more confident if he be able to test the acidity of the curd and to find it equal to that which on other occasions has been followed by the production of fine cheese.

Grinding. In grinding, the pieces of curd after passing through the mill [36] should be of uniform size, but the work should be performed slowly, otherwise damage may occur owing to friction or squeezing. The mill should be simple and easily cleaned. The ground curd is subsequently weighed and spread in the vat or cooler for salting—the salt employed being at the rate of 2½ lb. per cwt. of cheese, and quite dry and fine. Where the cheese is intended for early sale, and is to ripen early in consequence, 2 lb. may be found sufficient. Under some systems, however, where the work is quickly performed, or where it is protracted, a smaller or still larger quantity of salt may be used. There is a greater loss of salt in the drainage from pressure when the curd contains a large quantity of whey than when it is comparatively dry. Salt not only acts as a preservative, but it influences the action of the rennet, while it slightly affects the flavour. After the salt has been thoroughly mixed with the curd, the latter is ready for placing in the mould or cheese hoop [37] in which it goes to press.

36. CURD GRINDING MILL AND CURD COOLER
(Pond & Son, Ltd., Blandford)

Pressing. When the curd is placed in the hoop for pressing, its temperature should be 70° F. If the heat be greater, it is liable to lose fat under pressure. The student of cheese-making should take a lesson in the process of clothing cheese for the vat, of vatting, and of putting to press, as well as in bandaging after pressure is complete, the shape and quality of the cheese depending largely upon these processes. When in the press, pressure must be applied until the whey runs; it is then gradually increased for two or three hours, and left until the following morning, when it is clothed with a clean cloth, returned to the press, and the pressure again increased. This practice is followed until the end of three days, when the cheese is removed, bandaged, labelled with the date of manufacture, and such details as are necessary for reference, and taken to the ripening-room.

37. PRESSED-CHEESE HOOP OR MOULD

38. CHEESE PRESS (T. Corbett, Shrewsbury)

Cheese Presses. The best cheese presses [38] are made of iron—light, strong, and capable of giving both progressive and continuous pressure. With progressive pressure alone a crust is formed on the outside of the cheese, while the whey within may be enclosed and thus prevent the production of fine texture. The ripening-room should be kept at 60° F. to 70° F.—preferably by the aid of hot water pipes which can be controlled, stoves being most undesirable. The cheeses should be placed on clean wooden shelves, systematically turned, and their places changed from time to time from a higher to a lower shelf or vice versâ.

The Ripening of Cheese. The ripening of cheese, apart from the question of the influence of acid, the temperature of the room, and the quality of the milk, depends upon daily care and examination. A system of cold curing has been discovered in America, and Drs. Babcock and Russell, of the Wisconsin Station, have shown that it is a success; but it is practically unknown in this country, and until British experts are in a position to practise and demonstrate the process with equal success to that which we now achieve, it will be well for the English maker to continue to follow a system under which the finest cheese in the world is produced.

During the ripening process the insoluble curd becomes soluble, and the richer the milk in fat the more rapid is the change. If, however, milk be skimmed, that change is protracted, and the larger the quantity of fat removed the longer the time required, until when made from milk perfectly skimmed, a ripe cheese is neither mellow nor perfectly soluble. Ripening is due to fermentation, the work of bacteria. As the acid, the product of the lactic ferment, is diminished, greater energy is displayed by the casein ferments which decompose the albuminoid matter and liberate ammonia, which neutralises the remaining acid, with the result that solubility rapidly follows.

Cheese Yield. The quantity of cheese made per gallon of milk depends chiefly upon the richness of the milk in fat. In the New York experiments with rich milk the yield of cheese per gallon averaged 1·23 lb. varying from ·97 lb. to 1·4 lb.; while the water retained in the cheese produced from a gallon of milk averaged ·47 lb., varying from ·32 to ·63 lb. The following facts were ascertained from these and other experiments conducted on a large scale:

1. In America the quantity of fat bears a uniform relationship to the quantity of casein both in milk and cheese.

2. When rich milk was used, the loss of fat was smaller per cent. than when the milk was of poorer quality.

3. The cheese produced per pound of fat is generally uniform.

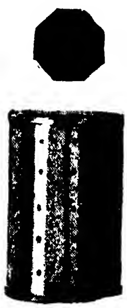
4. The weights of solids lost, and of solids recovered in making Cheddar cheese are almost identical.

Results of Experiments. Combining a large number of British and American experiments in Cheddar cheese production, we add the following highly important and closely-condensed results. It was found that the quantity of fat per pound of casein in cheese varied from 1·4 to 1·5 per cent.; that the loss of fat per 100 lb. of milk employed in making cheese varied from 6·3 per cent. in the case of extra rich milk to 10 per cent. in average factory milk; that the quantity of cheese produced per pound of fat in the milk varied from 2·67 to 2·75 per cent.; that the solid matter left in the whey for every 100 lb. or 10 gallons of milk used varied from 6·14 to 6·28 per cent.; and that the quantity of solid matter retained in the cheese from the same quantity of milk varied from 6·05 to 6·71 per cent. Approximately, therefore, the solid matter of the curd extracted from milk is about equal in weight to the solid matter left behind, chiefly sugar. Confirming this statement, we again point to the fact that the quantity of solid matter in the cheese for each pound of solid matter left in the whey varied from ·9 per cent. in the spring to 1·16 per cent. in October. The fat which was left in the whey per 100 lb. of milk varied from ·28 per cent. in June to ·42 per cent. in September, averaging about ·35 per cent.; while the quantity of casein and albumin left in the whey per 100 lb. of milk varied from ·64 per cent. in April to ·85 per cent. in October. When the milk contained from 3 to 3½ per cent. of fat, the fat left in the whey reached 9·5 per cent., while the cheese made reached only 9·1 lb. per 100 lb. of milk. As the milk increased in quality there was a systematic diminution of the loss of fat and increase of the cheese made, until the richest milk, containing 5 to 5½ per cent. of fat, lost only 6 per cent. of fat in the whey and made 13·6 lb. of cheese.

Some Practical Results in Cheddar Cheese Making. One of the best Scotch makers of Cheddar cheese, who supplied the writer with full details of his work for four years, for the conclusions of which we are able alone to find space, showed that when milking 100 cows the quantity of curd when ready for grinding practically averaged 1 lb. per gallon of milk, not reaching this figure in spring, but exceeding it in autumn. In this dairy 4 oz. of rennet are added to every 100 gallons of milk during the whole season, the curd being brought in 45 to 50 minutes, and heated to 98° F. in spring, the heat being gradually increased until it reaches 102° F. in September. Lastly, taking the results of many tests, it is found that the fat present in Cheddar cheese varies from 32 to 34½ per cent., and the solid matter from 62 to 64½ per cent.

Cheshire Cheese. Cheshire cheese, which closely resembles *Cheddar* cheese in appearance, except that usually it is coloured artificially, nevertheless differs in flavour and texture. It is made of three types: (1) the early ripening cheese, which possesses a stronger flavour, and contains more moisture, thus paying the producer a better price for his milk; (2) the medium cheese; (3) the long-keeping cheese. In the manufacture of Cheshire cheese the formation of acid is promoted by the addition of sour whey, usually 1 per cent., before the rennet is added for coagulation. The curd is cut larger in making the early ripening variety, while the whey is left in the vat longer. Less pressure, too, is applied, and the curd is not ground in the mill. In the manufacture of the medium type of Cheshire cheese the curd is cut finer than in the early ripening type; it is also ground, and subsequently placed in an oven when in the vat, or hoop, at a temperature of about 80° F., and not put to press until the following day, when it remains for some five days. In this case salt is used at the rate of 2½ per cent. In making the late-keeping cheese, coagulation lasts longer—some 60 minutes—while the curd is cut finer than in the medium variety, and subsequently ground, and when in the mould, or hoop, it is placed in the oven and submitted to a longer period of pressure. In Cheshire manufacture it is usual to increase the temperature of the scald from spring to autumn gradually. Cheshire cheese has a good market among the industrial population of Lancashire and the North, and by its production Cheshire farmers have become some of the most prosperous in the country.

Blue-veined Cheese. Unpressed cheeses, that are remarkable for the blue mould which runs in veins within them, are chiefly exemplified by *Stilton*, *Wensleydale*, *Gorgonzola*, and *Roquefort*. They are the production of pure milk, which should contain 4 per cent. of fat, milk of this character making a creamier, mellower, and heavier cheese. In the manufacture of Stilton and Gorgonzola the curd produced from the milk of two meals, morning and evening, is coagulated separately, and the curd subsequently mixed, although there are now many makers who produce Stilton from the curd of mixed milk instead of mixed curd. In Stilton manufacture the two curds are blended at about 60° F., while in making Gorgonzola the warm curd of the evening or morning is mixed with the cold curd of the previous milking. Two separate curds fail to cohere or unite like the curd of a single meal, with the result that interstices are formed, in which the blue fungus, *Penicillium glaucum* is enabled to grow. In the manufacture of Roquefort the growth of mould is encouraged by the addition to the curd of crumbs obtained from bread produced from barley and rye flour, upon which the fungus is already flourishing.



39. STILTON BOARD AND MOULD

Making Stilton Cheese. In making Stilton cheese the milk is allowed to stand hot from the cows until it has fallen to the required temperature, which varies from 82° F. to 90° F., the natural heat never being lost. Coagulation lasts 50 minutes, and when the curd is ready for removal it is taken in large slices and carefully laid in cheese-cloths, spread within shallow metal receptacles [41], where it gradually parts with its whey by gravitation. Subsequently, however, the four corners of the cloths are drawn together and loosely tied, the slight squeezing inducing the further drainage of the whey [32 and 33, page 4491]. Later, the corners are tightened slightly from time to time, as the maker finds necessary, the curd lying in the whey all the time. When drainage is sufficiently complete the whey is run off, and the curd, now comparatively solid, is laid in pieces in a vessel made for this purpose [41], and turned from time to time to assist it to mature; and it remains until the following morning, when, now soft and mellow, it is mixed with the curd produced from the milk of the previous evening, both lots having been broken into small pieces by hand and salted with fine dry salt at the rate of 2 per cent. By long exposure, the first curd has developed acid sufficient for the purpose of the maker. The mixed curd is next placed in cheese hoops, which are pierced with many holes [39 and 40], and taken to a warmer apartment, about 60° F., to induce it to drain. Here it remains, being turned from day to day, until it is fit to take out of the hoop, when it is bandaged with calico, each bandage being changed daily,

40. STILTON CHEESE DRAINING STAND, SHOWING DRAINING TUBE

until the coat or jacket-like crust begins to form on the outside, when it is once more removed, but to a cooler apartment, about 55° F., until the coat be fully formed. At this time change is again necessary, and it is removed to the ripening apartment, maintained at 60° F., which may be increased to 65° F. if it become necessary to hasten the ripening. Every cheese is turned daily and carefully examined, that it may be kept free from mites or flies, both of which should be excluded from the ripening apartments—an important feature in Stilton cheese manufacture. The ripening-room should be kept not only at an even temperature, but sufficiently moist to prevent the cheeses drying, and their consequent loss of weight and quality. From the beginning to the end of the process, the greatest possible care is needed to control the activity of bacteria, which are associated with dirt, and especially with unclean utensils. A large proportion of the Stilton cheese produced in England is spoiled as much from this cause as from want of knowledge of principles.

Gruyère. Gruyère, the leading cheese of Continental type so largely manufactured in France and Switzerland, where it is known as *Emmenthaler*, is to a large extent the product of milk delivered to factories by numbers of very small cowkeepers. The temperature for the coagulation of the curd is 95° F., while cutting begins in 30 minutes. After cutting, the curd is broken during the stirring process until it is about the size of a pea, when it is heated while in the whey to a temperature varying from 105° F. to 130° F. Salt is rubbed into the crust at the rate of $2\frac{1}{2}$ per cent. after the cheese is formed, it having previously been subjected to heavy pressure. In the process of ripening it is subjected to three temperatures, all of which should be under control—first to 60° F., then to 57° F., and finally to 52° F. The character and flavour of Gruyère is largely owing to the inoculation of the milk with the lactic ferment through the medium of sour whey. The eyes, or holes, of the cheese should be of medium size, bright, clean, and glazed, and the flavour should resemble that of a hazel nut.

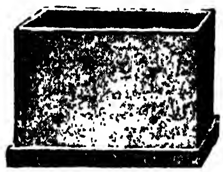
41. STILTON CHEESE ROOM, SHOWING THE CURD IN THE VATS
From a photograph by Mr. Loudon Douglas

Soft Cheese. Cheeses of the soft or unpressed type are made for consumption in a white or fresh condition, or they are ripened by careful manipulation and subjection for some weeks to well-controlled temperatures. As we have already shown, fresh curd is insoluble; but whether a cheese be ripened while young and fresh or when some weeks old, it is practically soluble owing to the change which has been effected by the action of mould or bacteria, or both. The brick-shaped Yorkshire curd-cheese common to this country, like the fresh Coulommiers of France (which is now made and sold in England), are types of the white or fresh curd-cheese; while Brie and Camembert are examples of the finest varieties of ripened cheese. In the manufacture of fresh or white curd-cheese, the curd obtained at a given temperature and in a given time is removed carefully while still tender into the mould, which gives it its form, and from which it parts with its whey by gravitation. Moulds are now usually made of metal, and in some cases pierced with holes [42-44]. They are placed upon mats of clean, straight straws to facilitate drainage, and are turned from time to time that the whey may escape from both top and bottom. When drainage has been sufficient to give firmness to the young cheese the mould is removed, the cheese is salted on its various faces, and turned daily in an apartment kept at a given temperature until, in three or four days, it has become sufficiently mellow and has developed a delicate flavour, which qualifies it for the table. A fully-ripened cheese, on the contrary, although subjected to the first processes already named, is allowed to remain in the first of the ripening rooms, usually termed by the French the *drying-room*, until it is covered with a white, velvety down or fungus, which in most cases is succeeded by the blue fungus (*Penicillium*), the action of which is to neutralise the acidity of the curd, and in this way enable the casein ferments, or bacteria, to complete the work of ripening and converting the insoluble into soluble matter. It may be mentioned that as the mould grows upon the outside of the cheese, so ripening begins from the outside, proceeding towards the centre, which when reached becomes thin, and may cause the cheese to run. The reason is that the outside being first neutralised the bacteria there first become active.

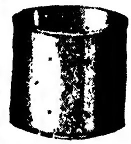
Brie. A brief description of the process of the manufacture of the chief of all French cheeses must suffice as an example in this particular department of the cheesemaking industry. Brie is a creamy whole-milk cheese about 1 in. in thickness and varying from

8 in. to 12 in. in diameter. It is made in the famous Brie district near Paris, and realises, especially in the season, very high prices, which are lucrative to the farmer. The milk employed in the manufacture of Brie cheese alone, comparatively insignificant as it may appear to the British farmer, is quite equal to that produced by the whole of the cows of two of many of our English counties. It is probable that in all good Brie dairies the milk utilised in this way realises an average of 1s. a gallon, or probably 50 per cent. more than the average realised by leading British dairy farmers. The rennet is added to the milk at 82° F. to 86° F., the curd being ready in from two to four hours, according to custom. It should be tender, and very carefully placed within the double metal moulds which are employed in this industry. These moulds consist of two round hoops, which average 10 in. in diameter by 3½ in. in height, one fitting into the other, so that when the curd is drained sufficiently, and its surface has fallen below the bottom of the top hoop, this is removed, and it then becomes possible to turn the cheese. Each pair of moulds is placed on clean straw mats, upon which the maker lays the curd in thin slices for drainage, the temperature of the apartment being about 62° F. When ready for turning, a clean mat is placed on the top of the lower mould, and the cheese inverted, and, salt having been spread over the cheese on either side, this practice is continued from day to day in the drying-room, which is kept at a temperature of 65° F., until the outsides are covered with white mould. Turning, however, still continues until the blue mould appears, as it does at first in spots or buttons here and there. Gradually, however, the whole surface is covered with blue, and in the best managed dairies with isolated spots of vermilion. The cheeses are examined and turned daily until, in about six weeks, they are sufficiently ripe for the market.

42 COULOMMIERS CHEESE MOULD (In two parts)



43. MOULD FOR BRICK-SHAPED CURD OR YORK CHEESE (Dairy Supply Co., London)



44. CAMEMBERT CHEESE MOULD

General Points on Cheesemaking. Whatever the variety of cheese that is manufactured, the process involved is one which resembles those already described in its main characteristics. From what has been said already it will be remembered that the time of coagulation, and consequently the quantity of rennet employed and the temperature at which the milk is set, influence the process of drainage, the presence of acid, and the general condition of the curd Fine cutting facilitates drainage, and pressure reduces the quantity of moisture, and consequently of sugar, which, being in solution, remains in the cheese to a larger extent where the moisture retained is larger in quantity. It follows, too, that the temperature at which the cheese is exposed during ripening involves differences in the process of fermentation, and apparently also in flavour. The famous *Pont l'Évêque* cheese of France is produced from drier curd than the Brie or the Camembert, with the result that its flavour is entirely different, and, although science has not yet determined the point, it is more than probable that flavour, like consistence or texture, is in part governed by the quantitative relationship of the solid materials of which the cheese is composed—*i.e.*, the fat, the casein, the albumin, the sugar, and the mineral matter. Investigations have been made recently in the United States in the hope of determining the cause of the flavour of Camembert. It is believed, although no proof is yet forthcoming, that the vegetable organism *Oidium lactis*, which presents a creamy appearance on the surface of milk, but which below the surface closely resembles the cells of yeast, is to some extent responsible. We have, however, much to learn; but until properly substantiated facts are forthcoming, the cheesemaker will be well advised to follow the recognised processes of the day as practised by the most skilful and successful manufacturers.

THE BEST BOOKS ON DAIRYING

"The Dairy Farm." By J. Long. (Cazenove. 2s. 6d.)
"Practical Dairy Farming." By Prof. J. P. Sheldon. (Bell. 1s.)
"Elements of Dairy Farming." By J. Long. (Collins. 2s.)
"The Dairy." By J. Long and J. C. Morton. (Vinton. 2s. 6d.)
"The Book of the Dairy." Translated from Prof. W. Fleischmann. (Blackie. 10s. 6d.)
"The Farm and the Dairy." By Prof. J. P. Sheldon. (Bell. 2s. 6d.)
"Manual of Dairy Work." By James Muir. (Macmillan. 1s.)
"British Dairying." By J. P. Sheldon. (Lockwood. 2s. 6d.)
"Handbook for Farmers and Dairymen." By F. W. Woll (U.S.A.). (Chapman. 2s. 6d.)
"Practical Dairy Husbandry." By X. A. Willard. (Kegan Paul. 15s.)
"Economics in Dairy Farming." By E. Matthews. (Newnes. 7s. 6d.)
"Milk and Its Products; Nature and Qualities of Dairy Milk and the Manufacture of Butter and Cheese." By H. H. Wing. (Macmillan. 4s.)
"Milk: Its Nature and Composition." By C. M. Aikmann, M.A., D.Sc. (A. & C. Black. 3s. 6d.)
"Milk, Cheese, and Butter." By J. Oliver. (Lockwood. 7s. 6d.)
"Cheese and Cheese Making, Butter and Milk." With Special Reference to Continental Fancy Varieties. By James Long and John Benson. (Chapman Hall. 3s. 6d.)
"Cheese and Butter Making." By J. Oliver and M. Barron. (Bemrose. 1s.)
"Dairy Bacteriology." Translated from Dr. Ed. Von Frendenreich. (Methuen. 2s. 6d.)
"Principles of Modern Dairy Practice, from a Bacteriological Point of View." Translated from G. Grotenfelt (U.S.A.). (Chapman. 10s. 6d.)
"Dairy Chemistry." By H. D. Richmond. (Griffin. 16s.)

DAIRY FARMING *concluded; followed by* POULTRY

HOW TO WRITE

Continued from page 4431

The Use of Words. "Style." The Only Way to Write is to Write Naturally. The Only Good Style is to be Unconscious of Style. Helpfulness of Reading

By ARTHUR MEE

IT is one of the mysteries of things that half the quarrels in the world, half the time of Parliaments and Law Courts, half the misunderstandings and confusions of private and public life, arise from the inability of men to say clearly what they mean. It could be proved, perhaps, that half the time and energy of the world is spent in explaining the meaning of words.

There need be no apology, therefore, for pausing in our study of journalism to consider the use of words. It would seem, at first sight, that nothing could well be simpler; yet the experience of men in all times and in all ages has proved that nothing could well be more difficult. The meaning of a word may be perfectly clear, so clear that, standing alone, it cannot by any process of argument be made to possess any other meaning; yet that word, placed in a sentence, may divide parties in the State and involve the time of judges and juries through weary months and years. It may be said that if language had been a rigid thing of geometrical exactness, if words had been things like locks and keys, fitting one place and no other, the whole world would have been different, and the history of the human race would have lost more than half its bitterness.

Say What You Mean. It is one of the first duties of the journalist to realise that words are fearful things; that the proper use of them is perhaps the most delicate art in which men can engage. "Say what you mean" is a counsel that might well be printed in letters of gold across the journalist's horizon. It is the work of the journalist to say what he means, and to say it so that, as Dr. George Macdonald says, it may not be mistaken for what he does not mean. Journalism has no room for the man who cannot say that two and two make four without creating some confusion as to whether they do not really make five. The man whose mental temperament will not allow him to say that a spade is a spade should be a lawyer or a quack politician rather than a journalist.

He need not trouble about "style." Style, like happiness, is not to be found by looking for it. Nobody can create it for him. It is not a thing that he himself can make. It will *come*, born of his genius, of the very nature of him. He can no more invent a style of writing than he can invent a style of talking, and his style of talking, unless he would make himself ridiculous, is that created for him by a greater power than he can contradict. The best answer that can be made to the young man who asks how to write can be put in a word: he should write naturally.

The Books that Help Us. That does not mean, of course, that he need not train himself to write, any more than to say that a man should live naturally means that he need not choose good food. We may carry the simile farther and say that, just as the man who eats well is likely to live well, so the man who reads well is likely to write well. Though a man's style must come of itself, he may prepare himself for it by a careful reading of books. It may be questioned, perhaps, whether his reading need even be "careful." It is probably true that a free and simple style comes most naturally and easily from a miscellaneous and unregulated kind of reading. In any case his reading should be wide in choice of author and subject, and should be sympathetic. It is a wise rule never to read anything as a duty; to put a book down the moment it ceases to interest. The books that help us are the books that *possess us* as we read them; the books we pick up eagerly and are loth to put down.

It does not follow that the books that interest us most will help us to write best. It is conceivable that a man may be held as in a trance by a story which may have no good writing in it. But we remember that we are writing here for the young man who is fitted for journalism, whose tastes will lead him naturally to the right books. He may be safely advised, at first at any rate, to leave alone books that have a "style." Somebody has told us of a brilliant man of letters who ruined his style and immensely lessened his influence because in his youth he was an enthusiastic admirer of Carlyle, and formed his style on Carlyle's; and it is probably a familiar case in the tragedy of letters.

The Journalist's Reading. The young writer will do well to read books which, by their simple language, have commended themselves to the mass of mankind. After all, it is the best test. The journalist who would be as a John the Baptist writing in the wilderness may choose his own way; the man who writes to be understanded of the people will choose the way of those writers who have reached the people's heart.

He will become familiar with Tennyson and Ruskin, and he will find no more helpful examples of the way in which our language can be tuned to music. He will be fond, very fond, of poetry. The English poets, said Robert Buchanan, were "his best and only guides," and a love of poetry is of inestimable value in learning how to write. He will take Mr. Birrell's advice, and never let a day pass without reading a really good bit of English—"an essay by Addison or Arnold, a sermon by Newman or Spurgeon, one of Cobbett's Rural Rides, or a letter of Cowper's." He will read fine passages

again and again, read them aloud whenever he can, and if he has not a natural ear for the music of words he will turn aside from letters before he adds one more name to the long sad list of men who have failed.

The Natural Gift of Writing. There is not a day on which some letters do not pass through the post asking an editor for advice on how to write. Too often, alas, they bear stamped on their face the certain evidence that no advice would be of any use. It is remarkable that there should be in the world intelligent people who imagine that a man may be taught to write exactly as he is taught to make a table. It is true, of course, that no man can write unless he has the gift within him. That is a gift which, however much it may be cultivated, can never be acquired entirely from without; can never be learned, that is, unless the instinct is implanted in the mind. An appreciation of this truth will save much disappointment. It is, perhaps, too much to say that writers are born, not made, but to some extent at least this is true. It is possible to take a man utterly ignorant of mathematics and make him an accountant; it is possible to take a man knowing nothing of mechanics and make him a capable engineer. But it is not possible to take a man with nothing in him of the genius of art or of language and make him a painter or a writer. The difference is the whole difference between acquired and natural faculties, and to this extent it may be perfectly true to say that writing is a natural gift.

Writing and Speaking. It does not, of course, follow that all who are naturally endowed with this gift know how to use it. They must still discover for themselves the poetry of language, the subtle way of conveying thoughts through words. They must still drink into their souls the spirit of great books. They must still learn the mystery of putting themselves—mind, heart, and soul—into the thing they write; of letting their pen be, as it were, the lens through which their thoughts fix themselves clearly and indelibly upon the sensitive mind of him who reads. It is a high ideal, which is not always present when we write, but it is this way that great writing lies.

No rules can make a writer, but the experience of many writers may help him. Perhaps the truest thing that can be said about good writing is that it is unconscious. We use words lightly in talking, not always realising their effect; but how infinitely more weighty is the word that is written! Yet the good writer is he who, conscious of the weight of words, still writes as freely as he talks, who writes as if he were talking, who sends his thoughts direct from mind to mind across space and time as across a table. It is the natural thing said in the natural way that makes up literature. The best letter writer is the man who writes to his friend as he would talk to him face to face; the best letters are those in which we can almost hear a voice, in which we can almost see a soul.

The young writer will hear much of the criticism that "that is all very well to *say*, but you must not *write* it." It is, of course, perfectly good criticism sometimes, but in the main he need not pay much attention to it. There is no essential difference between the language that is spoken and the language that is written, and those who set up such a distinction are generally to be found among writers who have no conception of freedom in writing, and whose style is portentous and awful beyond reading.

Journalese, the Unpardonable Style. The stilted and formal use of words is of all things most to be avoided. A word out of place is like a discord in music. A stilted style is like a bad tune. It is easy to fall into the appalling style of writing which we call journalese. It is far too common in newspapers and magazines, and even in books. It is the hall-mark of mediocrity. Its worst feature is the continual use of mild adjectives which have no meaning, of set phrases of which we are weary; the saying of things that mean nothing at all, and the dragging in of familiar quotations. A small vocabulary learnt by rote, a few stock phrases and quotations, are all the capital the journalese bore needs. If he is a reporter he speaks of the "lurid glow in the sky" at a fire, and of the "progress of the devouring element" being arrested when the fire is put out; at a wedding he tells us that the "bride won golden opinions," and was "the cynosure of all eyes." If a leader writer, he calls upon us to "read, mark, learn, and inwardly digest" his opinions; he "indulges in a few reflections," and "inclines towards" a particular view.

And it is not only in newspapers that we are bored to death by characterless writing which is a mere putting together of platitudes and phrases. Hundreds of books appear every year of which the publishers ought to be heartily ashamed. A book we have just read, with a large circulation and by a capable writer, is full of such phrases as *and which*, wrongly used in almost every case; and *different to* is almost as common among writers as among speakers. But even these things are more pardonable than the persistent and annoying use of colourless phrases and the painful searching after little-known words.

The Use of Simple Words. Nothing can be worse for a man who must earn his living by writing than to give those who read the impression that he paused once at least in every paragraph to look up the dictionary. There are men who use the right word instinctively but who, by sheer perversity of "style," will change it for another. They judge the value of their writing, apparently, by the obscurity of their words. If they think of a word which only one in ten can understand, they use it in preference to a word which nine in ten will understand, and think their achievement clever. It is as clever as the trick of the sign-writer who puts a letter upside down to attract attention to a quack medicine advertisement outside a chemist's shop.

The young writer will set himself sternly against these things. He will never use a hard word where an easy one will do. "All distinguished poetry," says Emerson, "is written in the

oldest and simplest English words"; and it is not less true of prose. Long experience has given editors certain rough-and-ready guides in forming estimates of a man's writing almost at a glance, and, though these are difficult to define, they have to do largely with such things as we are now considering.

The great aim of writing is to express meaning clearly and quickly, and the ideal article has not a wasted word in it. An excellent rule is to use always short words and short sentences, and there should be no striving for phrases and scraps of foreign languages. "There is nothing which can be said at all," says Mr. Christie Murray, "which cannot be said in English"; and nearly everybody will agree with him.

The Best English. There should be no ugly words, no jarring ends of sentences. Nor need the writer be afraid of repetition. There is a pernicious doctrine that repetition is bad, and good writers are found who would rather not write about a village than use "village" twice in the same paragraph. Any synonym rather than that; and, ransacking their minds for other ways of saying what they mean, they write hamlet, locality, district, neighbourhood, community, collection of houses. Let us make up our minds that when we want to say village it is bad English to say anything else, and that it may be perfectly right and good—as, of course, it *may be* wrong and bad—to use the same word in the same sentence half a dozen times.

It is not the good ear for words or the pure love of good English that condemns repetition, but a petty fastidiousness. "Nothing," says Mr. H. G. Wells, "could be more alien to the spirit of contemporary prose than for a writer to dodge among imperfect synonyms to avoid saying what he has and wants to say." It is this fear of using the word we mean whenever we mean it that has largely brought about the habit of saying *commence* when we mean *begin.* There is not the slightest excuse, save in very exceptional circumstances, for *commence.* It is condemned by the fundamental principle of good writing that a pure English word should always be used in preference to a foreign word; it is condemned, too, by that other principle of good writing that the short, direct word is always best. There is something much nearer to the origin of things in *begin* than in *commence. Begin* is much the prettier word. In the book of purest English in the world, the Bible, *commence* is not once used, though there are nearly a hundred *begins,* and one shudders to think how some modern writers would have destroyed one of the most beautiful phrases in all language, and begun the Bible with *In the commencement God.*

The Awkward Way of Saying Things. The importance of cultivating the practice of writing in short, clear-cut sentences can hardly be overstated. A good journalist never writes "yesterday evening" for "last night"; never speaks of an "electrically-drawn train" when "electric train" will do. He has found that the best writing is that which contains not only the fewest possible words but the fewest possible syllables.

It is possible to begin a sentence at the wrong end and still obey all the laws of grammar; but the writer who does that obeys the laws of grammar by disobeying laws of much greater importance. He might say "With the greatest optimism the man was inspired; the bridge was built by him all difficulties notwithstanding." We should know what he meant, but we should know it much sooner if he said "The man was inspired with the greatest optimism. He built the bridge in spite of all difficulties." The writer is telling us something about a man, and it is simply bad construction to tell us what that something is before the man is in our mind. The awkward habit of beginning at the wrong end is the enemy of smooth, facile writing. It destroys the music of language and the natural flow of phrases, and it recalls that worst of all habits—the attempt to force a style which will not come, for nobody speaks like that; nobody says "An up-hill one was his task." Even the man who wrote that would say in conversation "His task was an up-hill one."

It is the danger of studying style that it may produce a conscious style in the student, and nothing could well be worse. There are exceptions to all rules, and there are cases of men who have achieved a reputation by creating a purely artificial style of their own. There are successful writers who write in a manner which has become easy to them only after long effort. But we can never call their writing natural, and the mere fact that an artificial style has succeeded in rare cases is no argument in favour of forcing a style of one's own. The thing which is laboriously written, in which, as we read, we can almost feel the laborious effort of the writer to express himself, is not the kind of writing of which great literature is made. Thought expresses itself best and lives longest in a simple setting.

Grammar should be Used, not Worshipped. But, when all is said that can be said, the best advice as to how to write is that we should write without any consciousness of style at all. Words are the vehicles of thought, and the grammar of words is the science of expression. Grammar, however, is a tool, and not a master, and the writer will find that at times his rigid tool is imperfect and in the way. He must not destroy his freedom of expression, or interfere with the natural way of saying what he has to say, through a slavish devotion to a rule of grammar. He will find at times that euphony is of more importance than grammar, and will not allow the second best to destroy the best. Just as the painter must paint things incorrectly at times that we may see them as they are, so the writer must write incorrectly at times in order that we may read him as we should. Grammar is to be used, not worshipped, and though the freedom to ignore it is a very delicate licence that we may give ourselves, there are times when we may use the licence without any fear for our reputation. That, indeed, is perhaps only one more way of saying what we have been saying all along—that there are no perfect rules of writing

anywhere. It has all been put excellently well by Allingham, the Irish poet:

Not like Homer would I write,
Not like Dante if I might,
Not like Shakespeare at his best,
Not like Goethe or the rest;
Like myself, however small,
Like myself, or not at all.

Know More than You Say. We shall come to consider in due course the business of the journalist as a contributor to the magazines, but we may consider very briefly here, perhaps, the method of preparing an article. It is of the first importance that the writer should understand his subject thoroughly. A little knowledge, it is said, is a dangerous thing, and it is dangerous enough when the man with a little knowledge mistakes himself for an expert. But it is the journalist's business to have a little knowledge of many things, and it need not be dangerous unless he makes it so. His little knowledge must be used to lead him to sources of greater knowledge. We have already discussed the importance of his being able to master facts quickly, and to enter readily into any subject. He must have the gift of engrossing himself in his subject, of knowing all that he can know about it while he is writing. He should be as interested in an article as if it were a book; he should take as much pains with the one as with the other. He should make it a rule to know twice as much as he can say about his subject. Nothing is ever lost by thoroughness. Nothing ever known is wasted. The man who writes with the fulness of knowledge writes all the better for knowing many things which he need not tell.

Preparing an Article. Let us consider the genesis of an article. A journalist was called upon to write three columns for an important London morning paper, and had six hours in which to prepare his copy. He took up a little book just published on the life of a famous statesman, and went to his library. He found a strong human note in the book which appealed to him. He made up his mind to tell the moving story of this man's life. The journalist looked up his library index, skipped through two or three other lives of the statesman, dipped into the lives of two or three contemporaries and histories of the time, found a remarkable anecdote almost unknown in a book of gossip, looked up opinions and impressions of the statesman's work and character, and glanced rapidly through a history of the most important transaction in which he was engaged. It took him perhaps two hours to make his notes, but in the end he was stirred by the story in which he had lived for those two hours, and he sat down and wrote his article *with hardly a single reference to his notes.*

The lesson to be gathered from this is plain. The writer's thorough preparation for his work, the research and the making of his notes, made him so intimate and sympathetic with his subject that the writing became a labour of love.

Put Your Facts in Order. The journalist must always be prepared for research of the most thorough kind, and must have the means for this at hand. Once he is master of his facts his work is easy. The rest, perhaps, is not so easy as Robert Louis Stevenson would have us believe. "If," said he, "a man has every word and every sentence and every subject in the right order, and has no other gift, he will be a great writer," even though his clauses are unmusical and his words colourless and ineffective. That is a remarkable statement which it is difficult to accept as the deliberate opinion of a great writer, but it serves, at any rate, to emphasise the importance of having our facts in order. And not our facts only, but our thoughts and ideas, for ideas as well as words must harmonise and hang together. It is well to read a sentence aloud; reading aloud, indeed, is excellent training for any writer. One of the chief values of dictation is that it enables us to appreciate the sound of our phrases.

One thing the writer of an article should never forget. He should assume that his reader knows nothing of the subject on which he is writing. There are, of course, the most obvious exceptions to this rule. If the journalist is writing, for instance, in the LANCET, the rule clearly does not apply. It would be impertinent for a writer in the LANCET to assume, say, that his reader did not understand physiology, and to waste time in describing the simple anatomy of the body. But we are speaking of general journalism, of papers and books which make a universal appeal, and not of papers catering for select publics. In general journalism, that journalist will succeed best who appeals most strongly to the mind of his simplest reader.

The Journalist's Duty to His Readers. But we must guard ourselves very carefully here against misunderstanding. The writer in a newspaper is in the position of a man, let us say an artist, who is taking part in a conversation with, say, half a dozen people who have come together promiscuously, without any interest in common. Let us suppose that the artist is interested in the question of the weight of the earth. If he raises the subject in conversation, he owes it to all six to make what he has to say interesting to them all. But among the six is a scientist who knows more than the artist himself about the weight of the earth, and a clerk who knows nothing at all about it; and here his difficulty begins. If he addresses himself to the scientist he will probably be unintelligible to the clerk. If he addresses himself to the clerk, he may be uninteresting to the scientist. What he should do is to interest the clerk at once by explaining the matter briefly and clearly, and proceed to discuss the matter in such a way that the clerk will be able to follow him, while the scientist will listen because, though the facts may not be new to him, they will be stated so clearly and firmly that they may confirm him in some point, and the discussion of them may bring a new light to bear upon them. If, in all he has to say, the artist has in his mind the fact that the clerk knows nothing and the scientist knows everything, he is likely to appeal to them both and to interest the other members of the party whose knowledge of the subject is of varying degrees between the two.

The Readers of an Article. It is the same with the journalist. He will not, of course, be able to interest all the people all the time in all that he writes. Not even Shakespeare could do that. The man who writes a short article in a popular paper on the composition of the stars must not expect that Sir Robert Ball will turn eagerly to it and become engrossed in it. But the consciousness of this need not blind him to the fact that millions of readers know nothing at all about the composition of the stars, and that, though he cannot reach these millions, he will reach a public in which a large number know nothing at all about the stars, in which a small number have a vague interest in them, and in which a smaller number still are as interested as he is, and know as much as he knows about the subject on which he is writing. And he must set himself to write in such a way that the large number who know nothing about the stars may be attracted to the subject, that the small number who know something may read to learn more, while those who know all about it will read for the mere interest of reading on a subject they have made their own.

The Man Who Knows Too Much. The good journalist learns to write for the man who does not know in such an interesting way that the man who does know reads without in the least resenting the carefully hidden assumption of ignorance. It is because this aspect of writing is so important that an editor rarely asks an expert to write if he can get a layman, and the experience of editors has proved abundantly that nine times out of ten the amateur is much more likely to write a good article than the expert. It seems almost impossible for an expert to understand that there are people who do not know as much as he knows, or that some people know nothing at all. It may be argued, indeed, that the man who knows least about a subject, assuming that he is a good journalist, is the best man to write about it. He brings himself in touch with a fresh side of things; he puts an enthusiasm born of new knowledge into his work; most important of all, he puts the matter as it appeals to the mind of the average man, and it is for the average man that papers are produced.

We are not dealing with expert papers, where experts are not only desirable but indispensable, but it is true of general journalism that where the expert interests ten the ordinary journalist will interest a thousand, and an appreciation of this will help the journalist to make his appeal to the widest public. It is for him to gather all the fish that he can into his net, and to strike at once a note of keen and general interest. There is a story of an old preacher, hundreds of years ago, who startled his congregation by beginning "There was once a woman who brought forth 600,000 men at a birth." His congregation became alert, and the preacher was sure of their interest as he proceeded to tell them of the birth of Moses, "who was equal in himself to 600,000 men." That witty preacher had mastered one of the secrets of journalism. He attracted his audience, and the rest was easy.

The Value of Feeling in Writing. The young journalist will be well advised to write at first about subjects he knows intimately, always assuming that he does not cease to be a journalist and become an expert. The danger of the expert, who usually writes in a manner quite unintelligible to ordinary people, is not, however, very real in the case of the journalist, whose intimate knowledge of his subject is balanced by his equally intimate knowledge of his public. So that the danger of knowing too much about a subject does not exist for the man who is at heart a journalist, and the advantage of knowing all that he can is difficult to exaggerate. If the subject is something about which he feels strongly he will find it all the easier to express himself, and will be able to say what he has to say with feeling and force.

It can hardly be said too often that earnestness is more than half of a good style, and the man who is interested in serious things and writes about them interestingly is not likely to fail for want of readers. It is the habit of writing about trivial things as if they were important, of trying to force an interest in a subject without any inherent interest of its own, that is responsible for much of the mechanical writing in newspapers and magazines. There is a kind of article, to be found in many of the popular penny weeklies, which bores one by its everlasting sameness and its utter lack of interest or importance. It tells us how many cows' tails would reach to the moon, or how many halfpennies would cover the earth, or some other pointless thing without reason or interest or imagination. The journalist whose misfortune it may be to have to write these inanities for a living may be greatly pitied. He will find that the habit tells against originality and vigour of expression, and produces merely a weaver of ingenious calculations, with a useless capacity for spinning and twisting hackneyed words and phrases.

The Best Training. Newspaper journalism is perhaps the best of all trainings for a writer in any sphere. The journalist is called upon to write on all sorts of subjects in great haste, and he develops a facility for arranging his facts and interpreting their significance and their relation to each other which becomes invaluable. He learns the value of not overloading a sentence with thought, of not alienating attention from one point by dwelling too much on another. He discovers that his best work is usually that which is done most quickly. We may take it as a main rule that the best writing in our newspapers is done at high pressure, when moments are precious and printers are waiting, when the journalist sets down his impressions, with the first glow of his enthusiasm still upon him, so rapidly that he is barely conscious of the form in which he is setting them. It is then that the journalist puts his nerves into his work, and writes a thing which he himself has pleasure in reading when he opens his paper the next morning.

Continued

SOME VARIETIES OF TOOLS

Machine Cutters. Files. Grinding Wheels. Shearing, Detrusive, and Percussive Tools. Moulding Tools. Tools that Operate by Leverage

By JOSEPH G. HORNER

Rotary Machine Cutters for Wood. The saws may be regarded as the roughing or breaking-down tools of the woodworker. For finishing and imparting all shapes required to timber, the tools used embrace knives and moulding cutters of many forms. These owe their efficiency to the very high speed at which they run. The exceptions are the broad shaving knives used in planing broad surfaces, operating precisely as a carpenter's plane does, and removing similar shavings, only wider and thicker. The thin wood for boxes is generally planed thus in a suitable machine. The method of mounting rotary cutters is to bolt four usually on the flat faces of a four-side block, termed a *cutter-block*. This being rotated at a high speed, the cutters remove the material rapidly. The largest of these are employed for planing flat boards in machines of various designs. As they are often as much as 2 ft. wide, the power required is great—two to three horse-power for a small machine. Hence some blocks are fitted with knives to arrange spirally to give a shearing cut, or one in detail, which lessens the strain. Figs. **55** to **57** illustrate knives and blocks.

The knives and cutters used in wood-working machinery are sometimes scraping and sometimes true cutting tools. The spiral or shearing cut given in many cases, as in metal-cutting tools, ensures sweet working. Planer knives and moulding cutters are formed with a bevel, as seen in **55** and **56**, and the cutting is done by the junction of the bevel with the front flat face, the latter leading, as shown in **57**, which is an end view of a cylinder or cutter-block. In the *milled* cutters, or bits, the form is imparted by milling into the face of the steel, instead of on the edge, and they are set as indicated in **57** B, with the bevel the reverse way to ordinary cutters. In each case there is some top rake given by the setting on the cutter-block, as seen by the radial dotted line drawn in each example. The milled bits are sharpened by grinding the bevelled face, which does not alter the profile, nor does it reduce the thickness of the cutters. The ordinary cutters are ground on the back, and so get thinner each time. The cutters in **57** A are held by tee-headed bolts passing through slots into tee-grooves in the block; another method is that at B, where vee-clamps are made to embrace the bevelled edges of the cutters, and hold them firmly.

Circular cutters, which bear a certain resemblance to milling cutters for metal, are made with two or more edges, shaped to any profile which has to be moulded. Top rake is given. A few sections are shown in **58** of cutters having ten cutting edges, on five teeth, which permits of reversibility of rotation. There is practically no limit to the shapes which may be moulded. Grinding is done in the grooves between the edges.

Files. Files are not true cutting tools. The teeth faces are always set back slightly from the perpendicular [**59** A, B—A being a hand-cut, B the same after sand blasting]. These tools are divisible into two main classes, the *float* or *single-cut*, and the *double-cut*. In the first-named, C, the cuts are made in one direction only, diagonally across the file, so that the scraping action is continuous right across. In the second, D, the lines cut across each other at definite angles, and the action is effected by multitudes of isolated points. The first-named are used more for wood and for soft materials, the latter for metal. But for sharpening saws, single-cut files are often used, being an exception to the above rule.

The teeth of files vary in size from the *coarse* to the *fine*, the terms being relative, since the coarse teeth of one file do not correspond in pitch with the coarse teeth of another of different length, being regulated by the size of the file itself. The use of the rough file should always precede that of the finer ones, in order to economise time. A *rasp cut*, E, is a file in which alternate points take the place of rows of teeth. It is used only on comparatively fragile materials, as wood, horn, cores, breadcrusts, etc.

By virtue of the sectional forms of files they are able to produce numerous outlines—flats, curves, and combinations of the same. The file section is a counterpart of the shape produced, sometimes absolutely, but often only approximately, hence the large number of shapes in which files occur. There are about 3,000 different files made, if we include all sizes made in all types. The importance of the file in some classes of work cannot be exaggerated, notwithstanding that its functions have been invaded largely by the work of machine tools. The principal file sections are shown grouped in **60**, according to their mutual relationships. The principal longitudinal shapes are seen in **61**.

Sections of Files. In **60** we have sections which are related to the first in each row, the square, A, and the circle, P. A is termed a *square* file, B to D are rectangles, differently named, according to proportions; the *pillar* B a thick file, the *flat* C thinner, the *mill* D thinner again, and the *warding* file E very thin, used by locksmiths and in fine fitting generally. These are cut on all four edges, excepting in the *safe-edge files* in which one edge is left smooth, which is often convenient. The sections F to J are those of flat files which have special names, according to the form of the edges; F and G, with the

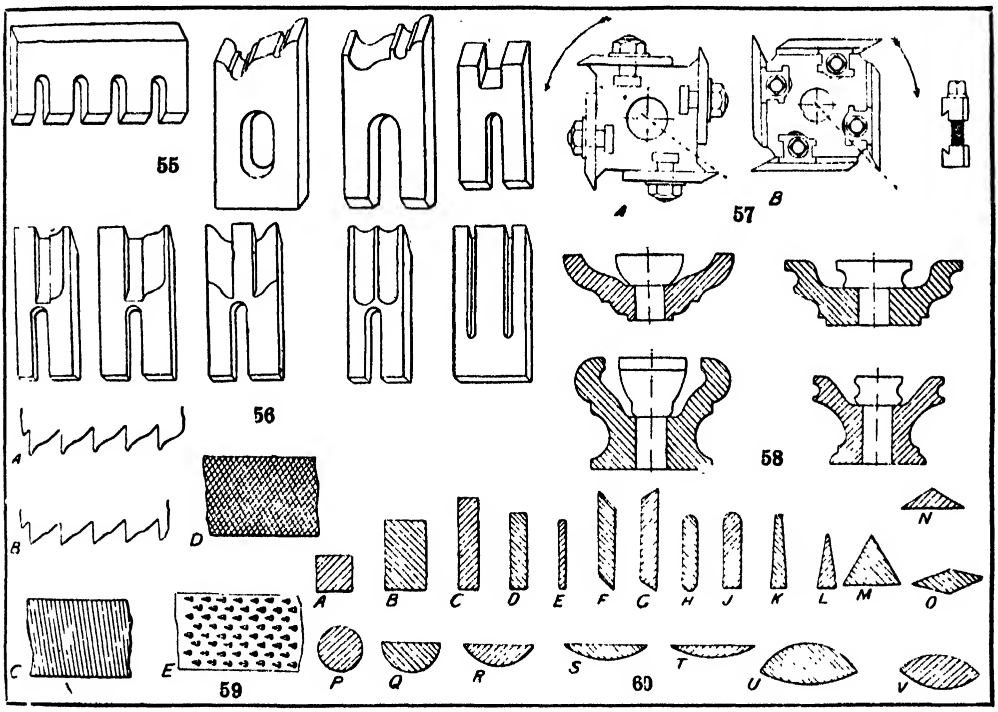
bevelled edges, are *swaged reaper* files. H and J are the *topping* files and the *mill* files respectively, used for sharpening and gulleting mill saws. The foregoing have parallel faces, but succeeding ones have not. These are the *reaper* file, K, the *knife*, L, both having the sections of truncated pyramids, the *triangular* or the *three-square*, M, of equilateral section, and the *cant* file, N. Two triangles combined, O, form the *slitting* or *feather-edged* file.

A file of cylindrical section is termed the *round*, P; succeeding figures show forms related to it. Q, semicircular in section, is a *pitsaw* or *frame* file, because used primarily by sawyers for gulleting and sharpening various saws; R, the *half round* is less than a semicircle; S, T, the *cabinet* files, are very flat half rounds, and U, having its faces of opposite but unequal curvatures, is a *crossing* file; and one with equal curvatures, V, is a *tumbler* file.

Longitudinal Forms of Files. Other terms are those derived from the longitudinal outlines of files. In the group 61, A is a *parallel* or *blunt* file. But it is not perfectly parallel, to which form the term *dead parallel* is applied, the blank for which is produced by machining. Absolute truth is, however, not very necessary in a file, since results depend greatly on how it is manipulated, and if very accurate results are desired they must be produced by scraping. What is termed an *equalling* file is one that has a very slight amount of longitudinal curvature. The *reaper* files are parallel. The *knife reaper*, B, has a handle forged on, instead of the tang usual in the files. If a file has much curvature it is *bellied*, C. Files that are termed *tapered* are bellied also, as the *square* file, D, and the *triangular*, F. E is the *parallel three-square* file. Half-round and cognate forms are also tapered or bellied, G, and parallel, H; so are the round sections, the *rat tail*, J, a tapered form, and the *parallel*, K. L is a file or rasp used by cabinet-makers, and termed a *riffler*. It is handled in the middle. The forms of rasps follow nearly those of files.

Grinding Wheels. These include natural or artificial grindstones, and wheels of emery, corundum, or carborundum, etc. The action of each particle is incisive though minute, and the total action is similar to that of the cutting tools in regard to the quantity of material removed and the accuracy of results. The grains in wheels of emery and allied substances are cemented in various ways, so that the cement does not dissolve in water, and the wheels are moulded and pressed into numerous shapes and consolidated so effectually that they run safely at surface speeds of 5,000 ft. per minute. The action of an emery wheel has been likened to that of a file a mile long moved over that distance in a minute. Hence, though each grain removes a merely infinitesimal quantity of material, the total results are such as to come into rivalry with those produced by the ordinary cutting tools.

The forms in which wheels are chiefly used are the *disc*, operating by the periphery, and the



CUTTERS AND FILES

55—58. Wood-planing and moulding cutters **59.** Teeth of files **60.** Sections of files

cup, by the edge, and each in several modifications and in a large range of dimensions. Wheels are used wet or dry.

Work Suitable for Grinding. Grinding wheels cannot be relied on to produce accurate profiles on repetition work, like form-milling cutters; but there are nevertheless a number of profiled shapes which are used for various straight and curved portions, especially in tool grinding operations, where the change in form is not sufficient to affect the results. The plain disc wheel shape, **62** A, is used more than any other; the profiled types include those of bevelled forms, B, C, and D, employed for work where the square edges of A could not be got in confined situations. These are used especially for cutter and saw sharpening. Curved outlines, E and F, are also used extensively. The sectional appearance of a disc wheel is indicated at G, showing the central bushing of lead. Wheels of this type may be several inches wide, or as thin as $\frac{1}{16}$ in., and vary in diameter from several feet to a fraction of an inch, in the tiny bush grinding rolls. Recessing, H, is often done in order to grind up to shoulders on cylindrical work, without fouling. Wheels are dished also, J, to overhang their spindles inwards, and so to lie more in line with the bearing of the spindle, a point which tends to obviate vibration. The same result is attained by dishing the wheel discs, as at K, which shows the end of a grinding head for a universal machine. Other dishings, L and M, are made to enable the wheel to reach out and operate on narrow edges of milling cutters, etc., grinding with the faces. This leads up to the cup wheels, N and O, which also grind by their narrow faces, the idea being that the speed of the wheel remains constant until it is worn out, whereas in the disc types, grinding by their edges, the diameter is constantly being reduced, and the speed of the wheel must be increased accordingly to obtain the proper efficiency.

Shearing Tools and Shearing Action. When two cutting blades are placed in opposition so that the face of one is in the same plane as the face of the other, the method of severance is termed shearing [**63** A]. The action is a truly cutting one, although the tool angles may be very thick, or from 80° to 85°. The action of the common scissors is identical, though the cutting angles are much less. The coincidence of the faces is essential to shearing, because if they were not, the material would be bent instead of cut, due to the lack of adequate support, as indicated at B. In the wire nippers, and in nippers for thin sheet metal, the cutting edges are in the same plane but do not pass each other, C. Strictly these are not shears, but chisels used in a particular way.

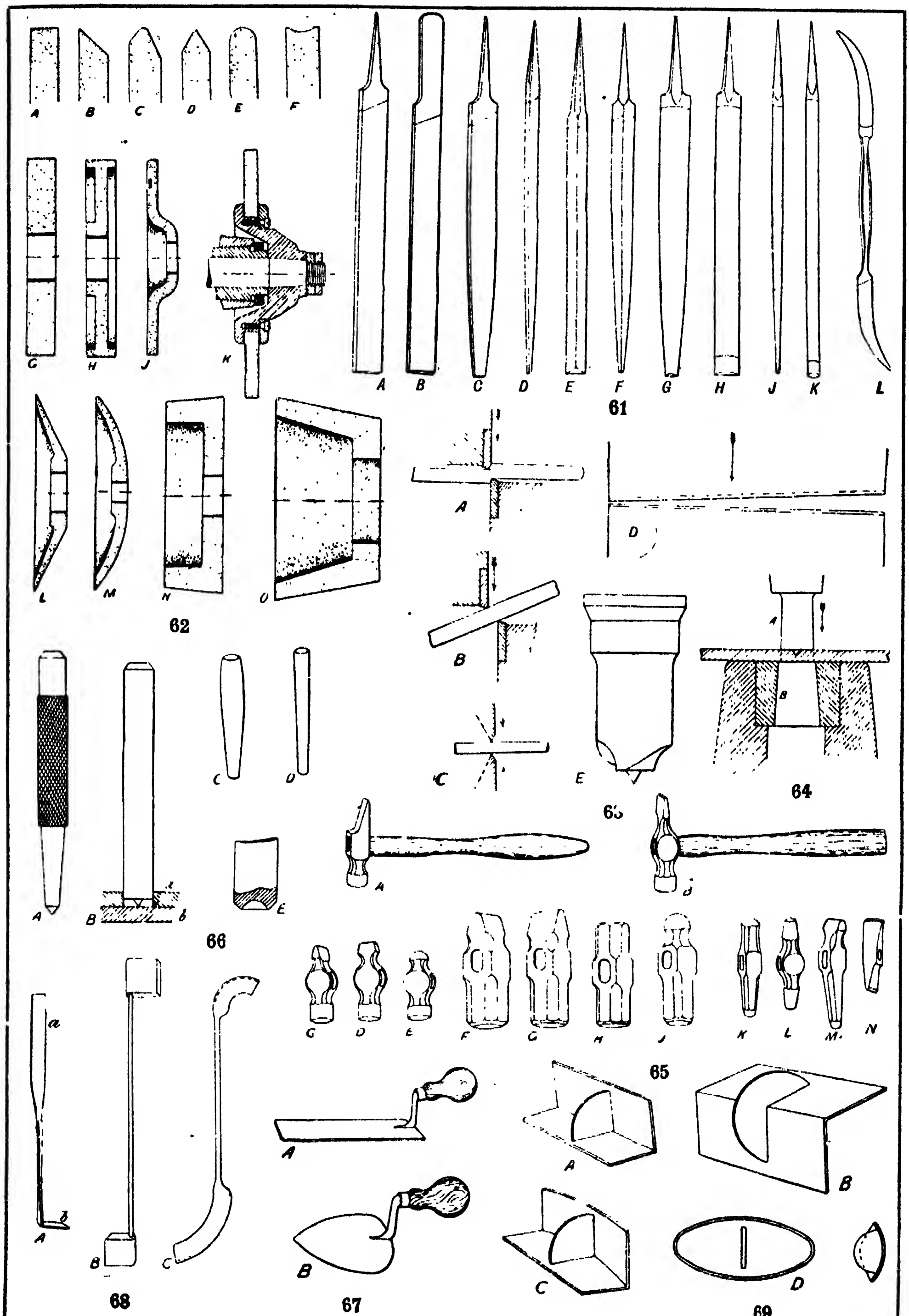
In the work of the engineer's boiler and plating shops, in bridge and girder construction, in the sheet metal work of the tinsmith and coppersmith, the shears in some form or another are in constant use. An inch thickness of steel is severed as readily as a tin plate, and as rapidly. It is only a question of strength and temper of blades, and stiffness of machines. The only alternative is the saw, either hot or cold.

The Shearing Cut. A *shearing cut* is not necessarily the same thing as cutting by shears. It signifies a cut taken in detail—that is, the act of severance does not occur along the entire edge of the tool simultaneously, but gradually from one end to the other, D, which indicates the longitudinal position of shear blades. Most shears for heavy metalwork embody this action. It takes place in the common scissors. Its importance can hardly be overrated. Some operations would not be practicable without it. Familiar instances are the shearing of thick plates of several feet in width, the cutting of profiled forms with diagonal edged form tools operated in the cross-slide of a turret lathe, the spiral teeth on wide milling cutters, the action of the Fox trimmer for woodworking, the skewing of the iron of a rebate plane, and that of many roughing tools for metal-turning and planing. Even in the plane there is a shearing cut. The slight convexity imparted to the edge is a true example of this kind, and the difference in the quantity of material removed by a well-rounded jack plane iron and a straight trying plane iron is well known in the economies of roughing down.

Detrusive Tools. Practically these are restricted to the punches, though shears are as truly detrusive in action as the punches are. In fact, if we consider a punch as a shear blade in cylindrical form, the analogy is perfect, for the punch is tapered upwards to give clearance. And if a spiral punch [**63** E] is taken and supposed to be unrolled, we have a shear blade with a shearing cut. Fig. **64** shows the common punch, A, in the act of penetrating a plate. It has no front rake, and therefore the operation is absolutely detrusive, whereas in the spiral punch [**63** E] there is a true shearing cut. The stress of punching is very severe, the metal of the *burr* or punching being partly squeezed into the mass surrounding. Support is necessary, which is afforded by the bolster, B, the hole in which is only very slightly larger than the punch for precisely similar reasons stated in connection with A and B, in **63**. The taper of the punch upwards is its clearance, to prevent sticking in the hole, and to help the severance, and the taper downwards in B gives freedom of escape for the burr.

Percussive Tools. These constitute a very large group which includes the hand hammers and mallets, the power hammers, and caulking tools. The hammers alone include some scores of distinct shapes, and most of them occur in numerous sizes. They may be classed best according to the trades in which they are employed, as woodworkers, engineers, smiths, coppersmiths, tinsmiths, coopers, etc. To illustrate these would occupy too much space, therefore a very few typical ones are shown.

The obvious function of a hammer is to strike a blow, hence the reason of the leverage afforded by the handle, which is short when manipulated with one hand; long when swung by both hands. The size and weight of the heads vary also in hand hammers and sledge-hammers, but the shapes of the faces which terminate the



VARIOUS TOOLS

61. Longitudinal shapes of files **62.** Sections of grinding wheels **63.** The shearing action **64.** The punch **65.** Hammers **66.** Centre punches and drifts **67.** Trowels **68** and **69.** Moulders' tools

heads is determined by the character of the work to be done, as are also the proportions and shapes longitudinally. Thus, hammers have flat faces—*flat pane;* or globular ends—*ball pane*, or narrow convex ends.

Hammers. The commonest hammers used by woodworkers are the Exeter [65] A, and the joiners, B, the latter being commonly employed by many trades, but in different proportions of length to size of body. The narrow cross plane is of value for driving nails in narrow spaces. C to E are the typical engineers' hammers; C the *cross pane*, D the *straight*, or *long pane*, and E the *ball pane*. They are often termed bench hammers, because used so much at the vice bench. But machinists and many other metal-workers also use them. F to J are the typical *sledge-hammers*, also *straight*, and *cross pane*, F and G; *double faced*, H; and ball pane J. K to M are boilermakers' hammers. They are narrow, to get into corners, their functions including riveting. Boilermakers also employ the hammers C to J. N is a *chisel-hammer* used percussively, and termed a *scaling hammer* because used for chipping off the hard encrusted scale from the inside faces of the plates of steam boilers. Many hammers have very broad faces for operating on large areas. To these belong the *planishing* hammers of the coppersmith, the *flatters* and *set* hammers of the smith and boilermaker, the hammers of the goldbeaters and the shoemaker. The huge power hammers have no resemblance to the foregoing, the hammer itself being absorbed in the machine. But both gravity and applied force above the hammers are employed to render the blows effective. Also the speed of operation in the small types far exceeds that of the human hand. And when with the hammer there is combined the matrix or die the results leave hand labour far behind.

Mallets. The mallets are hammers of wood. They have resemblances to the steel hammers in length of handle—short for bench use, and long for swinging, two-handed blows. They are used where metal would bruise the face of the material. For the same reason engineers have hammers made of lead, and of copper, for hammering on polished surfaces without leaving marks.

Centre Punches, etc. There is another class of percussive tool—the centre punch [66] A, by which centres are popped in work for chucking by, and by which the course of scribed lines is indicated more clearly and permanently than is possible by scribed lines alone. B shows a special adaptation of a centre punch, in which centres for rivet holes are being stamped on a plate, *b*, through holes already drilled or punched in an upper plate, *a*, with which holes the centres will be true.

Among detrusive tools must be classed the *drifts* [66, C, D] used for enlarging holes that have been punched, hence their bellied and tapered forms. Another detrusive tool is the *snap*, E, by which the tails of rivets are neatly finished, following the turning over, to be done by hammer blows. The smith's *flatter* is a hammer, only it is itself struck with a sledge-hammer. So are the various *fullers* and *swages*, which mould metal into shape by percussive action. The *caulking* tools of the plater, boilermaker, and pipe layer are percussive, being struck by hammer blows. And so are many other tools of which these are typical.

Moulding Tools. These include all forms by which materials of various kinds are shaped without cutting action. They are the most important tools used by the smith, as the fullers, swages, flatters, and the dies. They also include nearly all the tools of the moulder working in sand. Allied to these are those of the modeller working in plaster, some of those of the plasterer, mason, and slater, and of the artist's modeller.

Fig. 67 illustrates the common *trowels* used by moulders and in other trades for smoothing over broad, flat surfaces; A is the *square* trowel, and B the *heart* shape. Fig. 68 shows moulders' tools, A being a *cleaner* for smoothing sand deep down where a trowel could not reach, vertical faces being smoothed by the blade *a*, and a flat horizontal face with the part *b*. B is a cleaner reaching down also into deep sides, and bottoms; C is a *flange* sleeker for smoothing the edges of deep flanges, two different curvatures being provided at opposite ends of the tool. In 69, A and B are *square corner* sleekers for smoothing internal and external angles respectively. C is similar to A, but has one face curved to suit concave edges. D is a *button* or *bacca-box* sleeker. Each of these tools is made in different sizes and modified forms. But all alike are moulding tools, working in sand.

Tools Operating by Leverage. Besides tools already mentioned, in many of which leverage comes into play, there is a group which operate as levers pure and simple. To this class belongs the common brace or stock by which the wood-boring tools are rotated. The forms of these have been very much improved of late years. The pretty wooden brace, a century old, has had to give place largely to others of metal which will do what the wood brace cannot, namely, work in confined situations by means of a double-acting rachet; and some will bore in angular positions. The refinement of ball bearings also inserted in the handle, the head, and the tool grip avoids the friction inseparable from the old type. The tap wrenches, or double-armed levers by which screw taps are operated, belong to this group. These occur in many varieties, including the solid hole kinds, and those which combine provision for clamping the tap shanks firmly in the body; Pincers, pliers, and pipe tongs form another group of levers. The pincers are too well known to need description, but it may be pointed out that those with the flattish ends pull a nail out better than those with very convex ends. The pipe tongs are roughened or serrated in the jaws to grip the outsides of iron and steel piping. The spanners form another group.

Continued

BANK OFFICIALS

The Bank Manager and the Bank Clerk. Salaries. Codes and Cables. The Institute of Bankers. Examinations. Banking Abroad.

Continued from page 4444

By R. LAING

THE age at which the clerk enters the service of a bank varies somewhat—ranging generally from 15 to 19 years. As the duties first entrusted to a junior usually include the collection of cheques and other documents, it is desirable that he should possess sufficient physical strength and mental activity to prevent his being easily robbed of his valuable burden; in large centres the age of entry is consequently higher than in the country districts. An examination is usually undergone by the candidate for admission, but, except in special cases, this presents no difficulty to anyone of average intelligence. English banks doing business in foreign countries or in the Colonies recruit their staff from those of institutions doing an exclusively home business, being spared, by so doing, the trouble of tutorship. The age of entry in such banks is higher, but in nearly every case a limit—usually of 21 years—is in force. In such banks the staff is generally divided into two distinct classes—the home and the foreign staff, the members of the latter, after a certain period, proceeding abroad to take up their duties there.

Salaries. The salaries obtained abroad are, as a rule, higher than those in this country, but the seeming advantage may be greatly discounted by the increased cost of living and the danger to health which is probably incurred. As regards salaries in this country, the scheme on which they are based may be either a graded or a non-graded one. In the former case, when the clerk is given a certain rank, say, of junior cashier (cashier at a small branch), he will at once receive the minimum salary attached to such rank, rising by stated increments until he reaches the maximum applicable, at which he remains until promoted to a higher grade. The salaries, if the second method is in vogue, are not determined by the exact rank held by the individual officer.

Training of Juniors. The clerk at the outset may enter on a term of probation, at the conclusion of which, if his abilities are deemed satisfactory, he is placed on the permanent staff. It is not at all desirable that anyone should receive his early banking experience in a very large or even a moderately large office. In such a case he will be immediately set upon some routine task, the monotony of which will only be broken by a removal to another department, there to perform work of a similar nature. It will therefore be with great difficulty that he will gain any knowledge of the business as a whole, and, should he be a person of only moderate ability, or somewhat lethargic, the result will be a state of regrettable ignorance. A comparatively small office, doing, however, a varied business, whose senior officials have both the time and the inclination to instruct the newcomer, is best suited for the purpose. The junior will, in such a case, perform in turn all the office duties, and will, through the occasional absence of his seniors, have a good introduction to the responsibilities of the profession in which he is engaged.

Walk Clerks. In enumerating the divisions into which the staff of a large London bank fall, the first to be referred to are the *walk clerks*. The work of the clearing clerks has already been referred to, and it is the documents which do not come within the clearing that are dealt with by the walk clerks. The whole of central London is mapped out by each bank into various routes, each of them being termed a "walk." The cheques on the bank offices situated there are presented for payment daily by the clerk to whom it is given, the bills on firms within the area of the "walk" being also presented by him for acceptance or payment. Every morning the cheques and other documents are listed under the headings of the offices concerned, and balanced. On the clerk's return he accounts for his collection by a mixture of cash, cheques, or payment warrants drawn on clearing agents, and returned documents.

Pass Book and Ledger Clerks. He may, however, be set to keep a ledger or the pass books relating to it. This marks a distinct step in responsibility, as, in posting the various items he will be required to see that each is in order—*i.e.*, that the cheque is correctly drawn, endorsed and dated; that the signature of the client is not a forgery; and that the instructions regarding the account are not exceeded in any way. These duties (or some of them) may, however, be undertaken by the chief ledger clerk. The chief ledger clerk may also check each morning all the entries of the previous day; while the cancelling by means of a perforating machine of paid vouchers, and the subsequent sorting, will probably be undertaken by the youngest junior. The cheque forms for sale will be taken charge of either by an official in this department or by a cashier.

The work in connection with securities for custody or as cover for advances is usually performed by clerks of some experience. The securities lodged for safe keeping do not occasion much trouble, but great care requires to be exercised with regard to documents held as cover in offices where the amounts in question are large and the deliveries frequent. The loan ledger will usually be kept in the securities department.

Bill Clerks. The junior, again, may be placed in the bill department, to which is usually given a place of greater importance than that dealing with ledger accounts. The bill having

been passed for discount by some responsible official, the due date is found, the discount calculated and checked, the amounts, endorsements and stamp examined, the draft passed through the registers and the proceeds placed to the credit of the client. The posting of the discount ledger, the work attendant on bills received for collection, either from clients or other offices, the necessary advices to customers of bills dishonoured (with, perhaps, other correspondence), the making up of bill returns and the renewal of opinions on names appearing therein, will all be seen to by this department.

In foreign bills the amount is invariably payable so many days or months after sight. The due date in consequence cannot be ascertained until the draft has been remitted abroad and presented for acceptance, and no exact interest calculation can, therefore, be made. Bankers dealing with such bills payable in a country using British money charge in lieu of interest a percentage on the bill amount—*i.e.*, if their 60 days' sight rate is 2 per cent., the amount deducted from a bill for £350, at that currency, will be £7. The article dealing with long and short exchange sufficiently explains the procedure with regard to a bill payable in a foreign currency.

Correspondence Clerks. The clerks engaged in correspondence have a better opportunity of gaining a knowledge of the business in its different aspects than those in other departments, the greatest disadvantages from the clerk's point of view being the comparatively late hour to which his duties extend, and the fact that he is very much at the mercy of other departments. A knowledge of shorthand is usually not absolutely essential, the principal clerks in such a department being expected to be able to draft a suitable communication on an indication of its nature being given.

The youngest junior will be placed in charge of the postage desk, while the completion of printed forms (a large proportion of bank correspondence being of this nature), the keeping and indexing of letter registers, the despatch and confirmation of telegrams and the filing of letters received when finally dealt with (the numbering of each letter providing a check on their return from the other departments), claim his future attention until he is judged fitted to undertake the more responsible duties of correspondence. In banks whose offices are widely separated, duplicates of branch correspondence are despatched by the following mail, running numbers being also used.

Code Telegrams and Cables. In banks doing a large foreign or colonial business (invariably including a large class of transactions carried out by means of telegraphic advice) a special staff of officials will be entrusted with the duty of coding and decoding the messages despatched and received. The codes used may be either public or private, check symbols being also used. The translation of a code telegram received is best verified by its being recodified by another official into whose hands the original telegram has not come, the result arrived at by him, if no error exists, agreeing with the original code message. Cablegrams despatched are also checked in a similar manner. The codes in use will be constantly added to through the need of symbols being required to represent the names of new clients, special transactions, etc.; but if the transaction in question is not to be repeated, arrangements may be made on its completion to use the symbol again. All code telegrams received and despatched are confirmed and acknowledged by first mail opportunity, the full translation of each being given. Work of this nature calls naturally for the greatest care and closest attention to detail on the part of the officers concerned, a clerical slip having, perhaps, the most serious results.

Not included in the foregoing classes are the waste book clerks, the officer or officers whose duty it is to post the general cash book and ledger, the clerk who may be solely engaged in checking the bookkeeping entries of the previous day, the official or officials who may be entirely occupied with opinion work, the messengers—a uniformed body of officials regarded as quite apart from the clerical staff, and so on.

Cashiers. In an ordinary branch, an appointment to the rank of cashier entails a distinct promotion. In large offices, the cashiers, or the majority of them, will generally be junior to the principal clerks in the various departments; but in branch offices in which the duties of such clerks are undertaken by one official—the accountant—the cashier or cashiers are placed between this officer and the rest of the staff, the members of which correspond to the junior officials in the head office departments. It is essential that a cashier should be possessed of good address and appearance, and be able to despatch the business of the bank's clients with the least possible delay. Each cashier is responsible for the balance shown by him in his cash book (the actual amount on hand being frequently checked by a senior officer), an allowance against possible loss being probably made.

Daily Balancing. The cashier is not allowed (with the view to the prevention of fraud) to deal with any book other than his own cash book, and, in consequence, if he is a quick and accurate worker, he will always be the first of the staff to complete his day's duties, for, if no error has been made, the agreement of the balance shown in his book with the cash actually on hand will present no difficulty. Any difference will arise through a mistake in the entries in the cash book or an error in the intromissions with the cash. The first is bound to be discovered on comparison with the relative waste books, registers, etc.; and with regard to the latter the cashier will invariably discover an error relating to any documents or bank notes (if the numbers of the latter are recorded); but the payment of ten sovereigns instead of five is not so easily discovered and remedied.

A cheque left for payment by a walk clerk, the signature on which has been cancelled by the cashier, will be accepted by the former as unpaid on his returning for payment, if marked and

initialled by the cashier "Cancelled in error." To cancel the signature on a *bill*, however, precludes the possibility of the draft being returned; while the presenting bank may refuse to allow a cheque bearing a foreign endorsement to be so treated until sanctioned by its correspondent. The foregoing remarks apply also to documents received through the post or the clearing.

The Accountant. The succeeding grade is that of accountant, who is responsible for the work of the office being duly carried on, and who, in the absence of the manager, attends to the duties of the latter. An official on reaching this status is almost invariably empowered to sign on behalf of the bank, so that no delay may occur in the completion of any draft or receipt should the manager be at the time engaged. The qualities required in an accountant are of a somewhat different nature to those most required by the cashiers and the manager. A clerk whose capacity in carrying through and arranging the routine work of the office is admirable and whose grasp of the business is very good, but who is somewhat deficient in address if called upon to interview a client, or who cannot, through some unfortunate cause, occupy the position which, apart from his office duties, a branch manager is expected to maintain, will be better fitted to be an accountant at a large office than a manager of a small one.

The Manager. In all branches the final position is that of manager, the official attaining this rank receiving promotion afterwards in the shape of a transfer to a more important office. The principal duty of the manager is the continual receiving of the bank's clients, in the course of which he will have opportunity for the exercise of tact, if, for instance, he wishes to retain the custom of a client whose overdraft the head office desires to see reduced. His observation should be keen and his deductive powers good. The success attained by the manager depends on the ease with which he can adapt himself to the various individuals with whom he comes in contact; upon the interest he can naturally feel and show in their affairs; and upon the degree in which he possesses an intuitive insight into character; a temper not easily ruffled, a quick and ready decision, and a mind unprejudiced in business by personal feeling. The ability to take a clear-headed view of the future of a doubtful debt and the resolution to act accordingly, even to the extent of the drastic step of stopping the account, are not too common. To discover borrowers (of a kind) requires no exertion, but the attraction of deposits is a different matter, and the manager may spend a long period before forming connections leading to an increase in this class of business. The manager's responsibility may be restricted either as regards the total business or each particular item by a *limit* being fixed by the head office.

Arrangement of the Office. The banking hall, or general office, should, if the building is of more than one storey, be on the ground floor, the rooms above, if possible, being occupied by those members of the staff whose duties do not bring them directly into contact with the public. The windows, if the office is not roof-lighted, are usually found at the side of the room, with the desks at right angles to this wall.

The counter desks will be occupied partly by the cashiers, and partly by officials from the bill and other departments, to enable clients having business dealt with by these to be attended to with the least possible delay. Behind the cashiers the waste book and ledger keepers will be placed, the other officials being found behind the clerk who represents them at the counter; while the correspondence department will be accommodated at the back of the office. As many officials as possible should face the counter, the chances of theft being thereby greatly diminished, while the accountant should be able from his desk to survey the entire office.

Institute of Bankers. The office of the English Institute is at No. 34, Clement's Lane, from which forms for signature, syllabuses, specimen examination papers (a small charge being made for these), and all other necessary information may be obtained, and at which a large library is available for the use of members.

SCHEDULE OF EXAMINATIONS FOR BANKERS

Examining Body, Grade, Time and Place of Examination.	Subjects of Examination. Obligatory.	Subjects of Examination. Optional.	Fees and Age Limit.
English Institute. Preliminary. April. Various centres.	Political Economy, Practical Banking, Commercial Law, Arithmetic, Algebra, and Bookkeeping.	French, German.	5s. None.
English Institute. Final. April. Various centres.	Political Economy, Practical Banking, Commercial Law, Commercial Geography and History, Bookkeeping.	French, German.	5s. None.
Scotch Institute. Associates. March. Various centres.	Arithmetic, Algebra, Geography, English Composition, Bookkeeping and Bank Books, Exchange and Clearing House System and Rules, Note Circulation, Interest and Charges, Negotiation of Bills and Cheques, History and Present Position of Banking in Scotland.		None.
Scotch Institute. Members. March. Various centres.	Principles of Political Economy, Stocks and Stock Exchange Transactions, History and Present Position of Banking and Currency, Theory and Practice of Foreign Exchanges, Principles of Scotch Law and Conveyancing, Law of Bankruptcy, Mercantile Law, Law of Bills, Cheques and Deposit Receipts, Practical Banking (Correspondence Branch Supervision and Advances).		None.
Scotch Institute. Honours. March. Various centres.	French or German, British History, British Government and Constitution, English Literature, Outlines of General History		None.

The subjects of examination (open to members only) are given in Schedule on preceding page. Certificates are granted to those passing the final examination, certain prizes are offered, and various banks reward, either by money payment or otherwise, a successful candidate. The annual subscription for a member is 10s. 6d., and a fee of 5s. is payable on each occasion by anyone intimating his intention of sitting for examination, the payment covering all subjects taken at the time. Such notice must be given not later than February 28th.

It should be borne in mind that before any examination of the English Institute can be taken it is necessary that the intending candidate be elected a member of the Institute.

The Scotch Institute. The principal centres of the Scotch Institute are at 27, Queen Street, Edinburgh, and at 218, St. Vincent Street, Glasgow, where libraries are available for the use of members, associates, and intending candidates (on payment by the last of a fee). No fee is payable for examination nor is any subscription (ranging from 5s. 3d. to £1 1s.) due until the individual becomes either by election or examination an associate or member of the institute. The examinations take place at the end of March, ten days' notice being necessary, and various prizes and gratuities are offered by the institute and banks concerned. All needful information will be supplied by the Institute authorities.

Banking Abroad. In almost every new country there will be found a bank, established with British capital, whose head office is in this country, and whose inception was principally due to the exchange business resulting from our shipping trade, but which also transacts a large *local* business oversea. No attempt has been made to establish banks to carry on similar French or German business, although the great importance of Hamburg as a shipping centre has caused certain institutions to open agencies there. Most of the larger Continental banks, other than those of State origin, possess, however, for the efficient transaction of exchange business, a branch in London, and the number of such offices is being steadily added to. A further extension of this practice is, in some instances, carried out by the establishment and maintenance of offices in all the principal Continental centres, and even in those still more remote. The principle of State banking possesses abroad a greater vogue than in this country, the principal banks in both France and Germany, for instance, being of this nature.

The banking business carried on in the United States is greatly affected by the regulations in force, which are too complicated to be dealt with here. In no other country has legislation regarding banking and currency been so prolific as in the United States, and the present arrangement probably does not constitute finality in the matter.

London Bill Brokers. Reference has previously been made to the London bill brokers, but one or two important points in connection with their method of business have been left untouched. Their funds are wholly composed of deposits at interest, the rate allowed by them being greater than that of the joint-stock banks. The margin of profit obtained is, in consequence, small, and, owing to periodical fluctuations in the rate of interest, is liable to entirely disappear, although the trend of interest rates may, of course, result in an unexpected increase. The brokers keep practically no reserve. The rates obtained by banks on the employment, with bill brokers and others, of funds for which no use can at the moment be found, or which it is desired to keep liquid, have a considerable influence on the profits of the banks. A large proportion of the bank's deposits—its current accounts—are obtained at what is practically an unchanging rate—the expense of working, no interest being paid by the bank. If money is a glut on the London market, the employment of surplus funds may be attended with loss; but if a tightness is in evidence, a large margin of profit will be earned.

Future of Banking. Banking may be said to have, in a certain sense, very probably no future, for history is, after all, but the record of the repair of accident and error, and a Utopia has no need of a chronicler. The progress of banking in this country during the past few decades is one of steady and continued growth, and is almost entirely free from those startling incidents which lend a romantic attractiveness to its earlier story. Its wild oats have all been sown long ago; it has now reached a vigorous manhood; but it is to be hoped that it will never, with the commerce and industry of the nation at large, descend in course of time to a decrepit and enfeebled old age.

Books Recommended. The practical details of banking business are somewhat neglected in the literature available, but the following list, which can be supplemented from that given in the Institute of Bankers' syllabus, may be studied with advantage:

Clare's "A B C of the Foreign Exchanges," 3s.
Clare's "Money Market Primer," 5s.
Moxon's "English Practical Banking," 4s. 6d.
Rae's "Country Banker," 2s. 6d.
Bagehot's "Lombard Street," 3s. 6d.
"Money and the Mechanism of Exchange" (Jevons), 5s.; and parts of Gilbart's "Principles and Practice of Banking," 10s.

BANKING *concluded; followed by* INSURANCE

TRACK AND RUNNING STAFFS

Conditions of Employment. Duties, Wages and Prospects of Track Inspectors and their Subordinates. Engine Drivers and Running Shed Hands

continued from page 4381

By H. G. ARCHER

TO maintain the permanent way and works of a railway, an elaborate system of organisation, together with a large staff of officers and servants is required. The head of this organisation is the chief civil engineer. As a rule, the chief engineer is given a lieutenant, who is specially charged with the maintenance of way and works. Then comes a number of divisional engineers. The number of engineering divisions of a railway depends upon its size. For example, the London and North-Western, with 4,000 single-line miles, has eight, and the London and South-Western, with 1,700 single-line miles, three.

Inspectors and Gangers. Each division is subdivided into so many chief inspectors' districts, and each chief inspector has under him four or five sub-inspectors. Inspectors' wages are from 7s. 6d. to 10s. 6d. per day. Each sub-inspector takes from 20 to 50 miles of single track, or about half that number of miles in territory. Below the sub-inspectors are the foremen gangers, who earn from 4s. 6d. to 6s. 6d. per day. A foreman's length averages two miles on a double track, or about four miles on a single. Below the foremen, again, come the platelayers, or surface men (wages 3s. to 4s. 6d. per day), the number of whom in a gang varies according to the density of the traffic, and the consequent wear and tear of the permanent way, or the number of junctions and sidings which have to be maintained. It stands to reason that the gangs' lengths, say, between Waterloo and Clapham Junction, have to be far more strongly manned than those of remote single-line branches. However, it is estimated that, as a general rule, one man per single line mile ought to suffice. The foreman and platelayers patrol it at least once a day to ensure that everything is in perfect order. They have to see to the condition of the joints, gauge, or horizontal alignment of the track, general condition of running surface of rails, and security of all keys, spikes, screws, etc.

Most careful attention must be paid to the spacing of rail joints. Directly spacing is found to be wrong, steps must be taken at once to adjust the rails. Inspectors, foremen, and gangers are supplied with spacing gauges. The spaces per joint, with rails up to 30 ft. in length, are as follows: Hot (summer temperature), $\frac{3}{32}$ in.; moderately cool, $\frac{5}{32}$ in.; cold, $\frac{1}{4}$ in.

Weak Points of the Track. The rail joint is the weak point of the track—that is, the place least likely to withstand strain. If joints be allowed to get out of vertical alignment, they play pitch and toss with the wheels of a train. The correct horizontal alignment of the track is tested by gauging with special rods, and the proper degree of superelevation to be maintained by the outer rail on curves is ascertained in the same manner. Platelayers [4] set right, with the tools at their disposal, all and sundry defects which they chance to find in any of the foregoing.

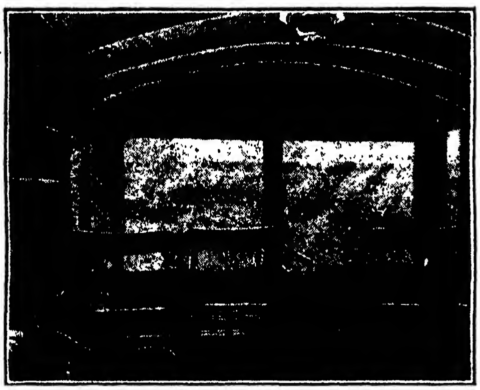
However, serious exception is now taken to the practice of entrusting platelayers with such a delicate matter as the adjustment of curves, which are originally laid out with mathematical precision, under skilled supervision. As in America, there ought to be a specially trained staff for the purpose, and we believe that one English company—the Great Western — is about to establish such a staff. Nevertheless, adjustment of curves, as conducted by platelayers, is not rule of thumb work. Every company issues a table setting forth the degree of superelevation in inches to be observed on curves of different radii.

4. PLATELAYERS "KEYING UP"

Duties of Platelayers, Foremen, and Inspectors. Further, platelayers have to move and repack the ballast, so that it may not concrete on the surface and hold water, to oil and clean the working parts of points and signals, and to keep in thorough repair all hedges, fences, slopes, drains, and "cesses" or footpaths. It stands to reason that the responsibilities of railway companies as regards fences and hedges are very heavy. Lastly, the platelayers have also to report anything they may detect amiss with the telegraph wires, signals, passing trains, bridges, culverts, notice - boards, quarter-mile posts, etc. The platelayer, of course, is an unskilled workman—a mere labourer, to begin with, and he learns his duties from a foreman. A man wishing to become a platelayer must be not less than 18 and not more than 35 years of age (which is the general rule with all railway companies in respect of ordinary labour); he must

be able to read and write, and possess sound health. There is also an eyesight test, but this is not of so stringent a character as with some other departments of railway employment. What are known as "half normal vision," as regards distance, and "defective colour vision," form the standard. On the whole, platelayers are a rather floating population. Many men stay in a company's service as such for only a few months at a time, then go off to join a contractor or another company, or perhaps to become ordinary labourers, and eventually return to put in another period of service with their original employers. A large number of platelayers is recruited from the employees of the contractors engaged in constructing a new railway—that is to say, the men who laid the line originally are taken over by the company *en masse* to maintain it.

Promotion for Platelayers. A platelayer can rise to the rank of foreman, inspector, and chief inspector, but any post higher than the

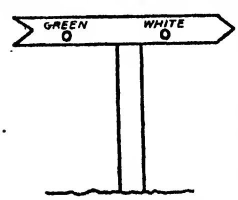


5. INTERIOR OF INSPECTION COACH AT REAR OF TRAIN
Showing seats for examining committee

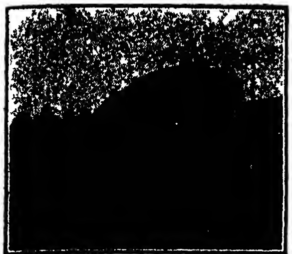
last-named he seldom attains, for educational reasons. Promotion rests entirely at the discretion of the company, and is judged by merit alone. The foreman, or ganger, is responsible for the work of a gang to his inspector, the inspector to his chief inspector, and the latter to the district engineer. By the way, among the younger school of railwaymen, great objection is evinced towards the old railway term "ganger." They seem to think it carries some reproach, suggests the idea of gangs in chains. Some companies are meeting the objection by calling the overseers *foremen* instead. Besides the platelayers and gangers who carry out all ordinary repairs, and therefore are known as "straight road" men, there are travelling gangs of ballasting men, or "packers," and relayers, who are employed in renewing the permanent way, and executing alterations and additions, when they are often strengthened by local men. About five per cent. of the whole permanent way of a railway is renewed per annum. The relayers, etc., are under the charge of chief inspectors, and each chief inspector also has allotted to him a complement of artificers, masons, bricklayers, carpenters, smiths, etc. (wages 6s. to 8s. per day), with their foremen and inspectors, who are responsible for the repair of everything that constitutes the "works" of a railway as differentiated from the permanent way. The sub-inspectors take charge of the relaying and repairing gang, when they get to work, are responsible for the discipline, hours of labour, and wages of every man temporarily or permanently employed within their districts, and keep a record of all materials received and used.

Relaying Precautions. Each gang of platelayers must be supplied by the inspector for the district with two red and two green flags, two hand signal-lamps, and a proper number of detonators. Before a rail is taken out, or relaying operations are begun, or if from any cause the line is unsafe, a flagman must go back, exhibiting a danger signal, and place three detonators on the line, 10 yards apart, at a distance of not less than one mile from the obstruction. Before a rail is taken out, the platelayers must have at the spot a perfect rail in readiness to replace it. In lifting the permanent way, no lift must be greater than 3 in. at once, and then it must be effected in a length of at least 20 yd. When both rails have to be lifted they must be raised equally and at the same time, and the ascent must be made in the direction in which the trains run, great care being taken, where there is a curve, to preserve the superelevation of the outer rail. Where the necessity for trains to travel at a reduced speed continues for a lengthened period, detonators and hand caution signals are dispensed with. In substitution thereof a warning board [6] painted green must be fixed in a legible position half a mile from the place to be protected. During the night one green and one white light are placed side by side on the warning board. When a lorry is run empty or used for conveying materials or men along the track, it must be taken in the same direction as the trains run, and followed at a distance of three-quarters of a mile with hand danger signals and detonators. On a single line the lorry must be protected in both directions, and in going through a tunnel it is signalled on the block instruments like an ordinary train. When not in use, the lorry must be taken off the rails, placed well clear of the line, and the wheels secured with chain and padlock.

Expert Scrutiny of the Permanent Way. Periodical inspections are made by the divisional engineers, the chief engineer, the general manager, and even the directors, to ensure that all the work is being properly performed, and a uniform standard of maintenance observed throughout the railway. Nevertheless, there is nothing definite about these periodical inspections by the higher officials, as is the case with Indian railways, where a divisional engineer has to certify



6. WARNING BOARD



7. ENGINEER'S INSPECTION COACH

that he has inspected every mile of track covered by his district at certain intervals.

Again, some of our readers may have noted passing references in the English newspapers to the grand field-days held by the principal railway companies of the United States for the purpose of inspecting the condition of the track and everything pertaining to it. The chief officers of the New York Central and Pennsylvania Companies spend annually two or three weeks travelling over their road in a special train, on which they live, eat, and sleep while the examination is being conducted. At the rear of the train is a large observation car, with seats arranged in tiers, for the accommodation of the various examining committees, whose duties are to scrutinise the condition of the permanent way, bridges, signals, stations, etc., and pronounce an opinion upon the general condition of the running surface of the rails. In the latter case, such a test as brimful glasses of water, which, of course, will spill over if the slightest oscillation be experienced, is applied. For the purpose of comparison, the whole extent of the line is marked out into the respective gangers' lengths, and the examiners keep scores testifying to the condition in which they find each. Premiums are awarded to the inspectors of, and every man employed in, the prize sections.

There is more in the system than meets the eye. The principal object in view is to bring down the unit of expenditure as regards the cost of maintenance and renewal to individuals—not highly-placed individuals, such as the district engineers, but the inspectors of districts, and even the gangers, who are entrusted with the care of only a few miles of the road. It is realised that the latter are the men who really hold the purse-strings, hence it would be a great thing to find out what they are giving for their money, and compare the different results. With the customary method of keeping accounts it is practically impossible to arrive at the details of expenditure on permanent way.

8. [illegible] BAR-BOY [illegible]

Premium Award System. The London and South-Western Railway has furnished the first instance of a British railway company adopting the American system of track inspection, with the view of splitting up and checking the expenditure that falls under this head, and at the same time trying to obtain better results for the same or less money. The system lends itself to raising the standard of efficiency from the highest to the humblest ranks of the army of men entrusted with the maintenance of the permanent way.

There is only one way to make the men at the bottom understand that better things are expected of them—convince them that their work is going to be individually examined and compared every year by the head officials. There is only one way to make them turn out better work than previously—namely, by instilling them with a new spirit of emulation, and encouraging them with the offer of money and other prizes.

A Common Factor of Responsibility. Everybody's responsibility is reduced to a common basis by charging him with the equivalent single-line mileage he has to maintain. He has so many running miles under him, including miles of sidings, of which two miles are estimated equal to one mile of running line, and he is allowed to reckon one mile of running line for every fifteen pairs of switches.

9. LOCOMOTIVE ROUND HOUSE

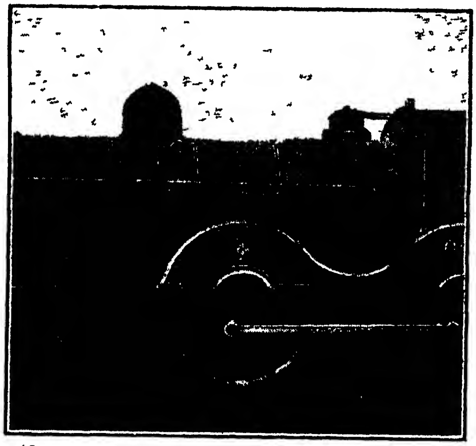
The chief engineer's road-book is arranged in consecutive order of inspectors' sections, as follows: (1) geographical beginning and ending of the section; (2) sub-division of running lines—that is, mileage of single, double, triple, or quadruple track; (3) total in single line miles; (4) total length of sidings; (5) number of switches; (6) total equivalent of switches in single-line miles. Next come particulars as to the manning: (1) names of the foremen, and their rates of pay; (2) number of men under each foreman, and their rates of pay; (3) total equivalent single-line mileage divided by the total number of men in gang, which produces the ratio of manning per single-line mile. It will therefore be seen that for comparative purposes the unit of expenditure is brought down to the inspector of a section. What is yet wanted is to bring it down to Foreman Smith or Brown, but that is still some way ahead.

A British Track Inspection. The track inspection occupies about eight days, spread over

a month or six weeks in the spring. The main line can be examined only on Sundays. Three examining committees are formed as follows: Class A, for condition of joints, alignment of track, and general condition of running surface of rails; Class B, for condition of ballasting; Class C, for general appearance of all works, including hedges, fences, slopes, drains, "cesses" or footpaths, notice-boards, and quarter-mile posts.

The system of premium awards instituted by the London and South-Western Railway offers a challenge cup and a money prize of £2 for the best inspector's section, and a challenge cup for the best foreman's length throughout the line. With the challenge cups go silver medals to keep In each inspector's section the foreman with the best length is awarded £1 and a bronze medal, while each man under the prize foreman receives 10s. and a bronze medal.

The Method of Marking. Let us see how the awards are arrived at. The line is divided into the respective gangs' lengths, and so many marks are allotted to each foreman under the three different classes by which his work is judged. Thus, in Class A, 200 marks represents perfection; in Class B, 120; and in Class C, 80. But the method of marking makes allowance for certain correcting factors. It is manifestly to the advantage of a railway company to get the work efficiently done by as few men as possible, and, as already stated, it is calculated that a ratio of one man per single-line mile ought to suffice Therefore, one mark is allowed for every hundredth of a man below one man per mile, and one mark is deducted for every hundredth of a man above the quota. The feeling among the men is that the age of the road also ought to count for something. Therefore it has been decided to apply another correcting factor in this respect. The average life of the road is assumed to be 17 years. For each year over 17 years five marks are added to the score, and for each year below two marks are deducted, the object of the discrepancy, of course, being to encourage men to take pains with sections of old road The weak point of the system is that it has not yet been found possible to apply other correcting factors in respect of density, weight, and speed of the traffic passing over the different sections. Obviously, a man whose section carries, say, 6,000 trains per mile per year, is not so hardly hit for wear and tear as his fellow whose section carries, say, 12,000 trains per mile per year. Further, the weight and speed of the trains in question ought also to be measured. This forms a good instance where the ton-mile statistics, instead of train-mile statistics, would prove invaluable were they but available.



10. CLEANERS AT WORK ON EXPRESS ENGINE

The Inspection Train. The special inspection train is made up thus: engine, inspection car, "resting" saloon, refreshment saloon, inspection car. The inspection cars [7] are four-wheeled vehicles, so that all shocks from the road may be transferred to the body, and provided with glass ends, so as to furnish a clear look-out. Only the inspection car at the tail end of the train is used for examining.

The interior of the inspection coach [5] is fitted up with two tiers of chairs, arranged in two pairs The examiners sit with their backs to the engine, and scrutinise the receding track. The committee for the condition of joints, etc., occupy the seats in the front left-hand corner, and the committee on ballasting those in the front right-hand corner, while the committee on the general appearance of all works sit in the back tier and look over the heads of the two former. To ensure impartiality, no examiner is connected with the section he is examining The committees, who usually consist of two members apiece, are on duty for about an hour at a time, and at the expiration of their turn the members leave the inspection car for the "resting" saloon, and their places are taken by others.

Inspecting the Line. The inspector of each section is in the inspection car while it is passing anywhere over his own length He has already marked out the various gangs' lengths, by means of white painted crosses at the side of the track, and now has to stand behind the examiners to answer questions and to give timely intimation of the change from one ganger's length to the next, mentioning each of his foremen by name On taking their seats, the secretary of the inspection has handed to each member of the three committees the whole of the award cards which they will respectively require for their turn of duty. The cards for each class are of different colours, and there is a separate card for each ganger's length. On the face of the cards are full particulars of each gang's length, together with information concerning the age of the road, weight of rails, etc., and at foot are spaces for the examiners' notes and awards. At the expiration of their turn of duty, the examiners return their cards to the secretary.

Success of the New System. The results furnished by the new system of track inspection, even at this early stage of its development, have been of a most gratifying nature. True, some of the older men are hostile to the innovation; but, taken as a whole, the

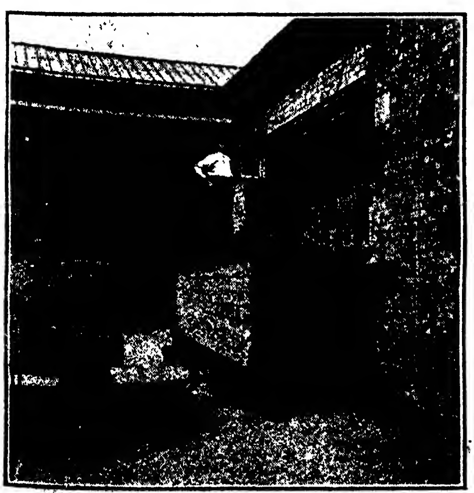
permanent-way staff has realised the importance and value of the new methods. There is no lack of evidence that since the system was inaugurated a new spirit of efficiency has impregnated all ranks, and the keenest rivalry may now be said to exist as to who shall earn the distinction of turning out the best stretches of road.

Running Sheds Staff. The headquarters of every individual connected with engines is one or other of the running sheds, or locomotive stables. It will be easily understood that engines are distributed in no haphazard fashion over a railway; on the contrary, each engine works within some well-defined area, of which the base of operations—the place where it is cleaned, prepared for the road, washed out, and kept in repair—is a running shed. A number of British railways find it useful in locomotive operation to paint the shed number on each locomotive, a good practice, followed by the London and North-Western, being to use a small enamelled plate bearing the number of the shed in which the engine is stationed at the back of the roof of the cab. An older, but still much used method is to paint the name of the shed on the engine frame or on the lamps. The running department of a railway comprises several divisions, each of which is in charge of a district locomotive superintendent, who is responsible to the chief locomotive or mechanical engineer. The office of a district locomotive superintendent is situated, as a rule, within the precincts of the principal running shed [9], from which he commands all other running sheds in his district. The regular staff of a running shed is distinct from enginemen proper—that is to say, it comprises a number of men and lads who are not passing through certain grades in order to attain footplate positions, although that may have been their original intention.

Skilled Workmen. The district locomotive superintendent's lieutenants are a head locomotive foreman and several sub-foremen,

11. TAKING IN COAL

and also a very important officer in the foreman fitter, who is responsible that engines leave the shed mechanically sound. To the foreman fitter is allotted a staff of skilled workmen, in the persons of copper, brass, and boiler smiths, who execute all ordinary repairs. The boiler-smiths are drawn from the most skilled artisans, as everything depends upon the efficient tightening up of tubes, hardening of stays, etc. The ranks of the less skilled labour employed consist of tube-cleaners, boiler-washers, lighters-up, sand-driers, and coalmen, who are under assistant shed-foremen. Stationary engine-drivers are found at all important sheds in charge of engines pumping water and driving repairing machinery, and they, of course, represent another branch of skilled labour. It may be thought that by opening with some description of the regular staff of a running shed we are putting the cart before the horse. However, the reason is that many railway companies recruit for the foregoing phases of more or less skilled labour from enginemen who have failed to continue a footplate career owing to defective eyesight or inability to obtain a driver's certificate, but some—notably the Great Central—enlist the regular staff of a running shed independently; men are engaged as labourers, and work their way up, or are taken on at once as fully-qualified fitters, smiths, mechanics, etc. In any case, however, men who break down on the footplate are given better positions than labourers. It is customary to put them on stationary engine work.



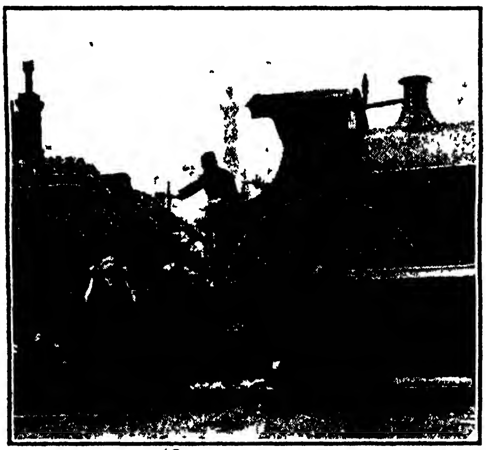
12. SAND DRIER

Bar-boys and Cleaners. A boy wants to become an engine-driver. How does he set about it?

The lowest rung of the ladder is bar-boy [8], rising to cleaner. The duties of a bar-boy are to creep through the fire-hole door of an engine, with a torch lamp, steel broom, scraper, and fire-bar lifter, to arrange the fire-bars, and to clean the bars, brick arch, roof stays, and tube ends of clinkers and ashes. However, many companies no longer employ lads under 18 years of age as bar-boys, since factory legislation prohibits them from being engaged in night work. In such circumstances, the youths of smaller stature who enlist as cleaners begin with bar work. When genuine bar-boys are employed, the age limit is 15, but candidates seldom have to pass a medical examination or eyesight test. When a bar-boy

is old enough to be promoted to cleaner, or, in the case of companies which begin with older lads, a lad presents himself to be taken on as cleaner, his age, height, physical and optical fitness, and educational proficiency are taken into serious consideration. Generally speaking, a cleaner must not be younger than 16, and not older than 21; he must be able to read and write; he must be physically sound; and he must pass one or other of the standard eyesight tests for colour and distance with both eyes. The standard of height varies with different companies; with some it is 5 ft. 4 in., and a promising boy a little below that height will not be rejected; while others have a rigid rule—5 ft. 6 in. without boots. The duties of a cleaner are to clean an engine as soon as it returns to the shed [9], for which purpose he is supplied with oil, waste, and tallow.

The Grooming of Engines. Sometimes cleaners [10] work in gangs of four, the senior of them being known as chargeman cleaner. In that case, one takes the wheels and framing, another the motion, another the "top" (which includes everything above the footplate), and another the tender. It takes several hours to clean an engine, and it is just as easy to clean it the wrong way as it is to groom a horse the wrong way. The art of cleaning lies in not delaying the hot work, when the oil and grease can be easily rubbed off, to do the cold work. The general rule now is for passenger engines to have their own two cleaners, while some companies go farther than this and book certain cleaners, sometimes one, more often two, to every kind of engine. Young cleaners are first put on to tenders, and occasionally they are classified separately as tender-lads, from which they are promoted to cleaning shunting, goods, and passenger engines respectively. As a rule, the cleaner's job is piecework, and he is paid according to the class of engine on which he is employed. For example, a half-crown is the ordinary scale of remuneration for cleaning a goods engine, while the work on an express engine is rewarded generally with 3s. 8d. In order to reduce labour, and consequently expenses, many companies give their shunting and goods engines a more sober livery than that of the passenger type. Should a cleaner discover any mechanical flaw, he must immediately report the same to the foreman cleaner, and some companies stimulate vigilance on the part of the cleaners by offering suitable rewards. The satisfactory completion of a cleaner's job is certified by the foreman cleaner of a shed. The foreman has a card, on which he ticks off each engine that passes his scrutiny. A cleaner is not allowed to leave the shed until the foreman has given him a pass which testifies that he has cleaned his engine properly.



13 LIGHTERS-UP

Promotion from Cleaners. A cleaner's length of service is entirely a company matter, with some companies it is purely a question of traffic exigencies—that is to say, if business be slack, a pass-cleaner will have to wait until it revives before being promoted to the footplate; while if business be extraordinarily brisk, a really promising youth may be promoted after cleaning for only twelve months. In ordinary circumstances, however, we should say that the average length of servitude as cleaner is three or four years, that very few cases of promotion occur till a lad has served 18 months, and that most companies are averse to promoting cleaners under 19 years of age, or until they have served two years, by which time they are expected to be pass-cleaners.

Then, the rank to which a cleaner is promoted is not always the same. A few companies advance him to fitter's assistant, meaning apprenticeship to a skilled mechanic for a period, during which he is executing repairs, and obtaining some first hand knowledge of locomotive machinery. But the tendency now is to employ none but permanent men in the fitting department of a shed. It is argued that a cleaner promoted to fitter's assistant is apt to lose touch with the footplate, and that the fitter himself is handicapped by having a constant succession of fresh mates. Therefore, the usual thing is for a cleaner to be promoted to shunting fireman. Shunting engines are employed in marshalling goods waggons and the vehicles of passenger trains. On their footplates the young fireman learns how to handle the shovel, injector, and brake, while he becomes well acquainted with the directions conveyed by signals.

The Fireman's Career. After a fireman has served his apprenticeship on a shunting engine, he passes through three higher grades in the same capacity; first, on engines working local or "box" goods train, or in those engaged in "banking"—that is, assisting all kinds of trains up inclines; secondly, on engines hauling main-line goods and mineral trains; and thirdly, on engines in charge of slow and express passenger trains respectively, according to his ability and experience. Some companies differentiate these three classes of firemen by name — third, second, and first-class fireman; others, again,

classify them by their length of service—namely, first year, second year, and third year fireman; but, whatever the names or methods of classification, the three grades invariably exist in actuality. Usually, when a man becomes a first class, trained, or pass fireman, he is expected to undergo an examination which proves him to be capable of taking charge of an engine if required. Some companies do not wait for him to attain that rank. For example, on the North-Eastern, after a man has been firing seven years he is due to pass as driver, and that examination he must then pass, or else leave the company's service. He is given three chances at intervals of three months.

Promotion for Firemen. The Great Northern Company, however, do not permit a fireman to present himself for the driver's examination unless there is actually a vacancy, or is soon likely to be one for him. Of course, every company is bound to keep a certain number of firemen qualified to act as drivers in reserve. Broadly speaking, companies employ their own discretion as to when they shall call upon a fireman, and it goes without saying that they limit their choice to men who have had considerable experience. With some companies, like the Midland, seniority counts for little; their aim is to pick out the men with a genius for driving.

While men are firing they have the opportunity of attending improvement classes. These are formed and managed by the men themselves, but the authorities are always ready to provide them with working models, and also to place an engine in steam, to be treated for all manner of imaginary mishaps, such as a broken piston, or valve, at their disposal. It should be added that some companies make a man pass an examination in the mechanical working of the locomotive even before he can attain the highest rank of fireman, when, moreover, he has to prove his ability to carry out slight repairs with the tools at his disposal.

14. CLEANING OUT THE SMOKE-BOX

Work of Locomotive Firing. There is considerable difference between firing a goods and a passenger engine. On the latter, a fireman has to accelerate the speed of his movements and economise time by thinking beforehand. The fireman of a modern express has not much time in which to admire the passing scenery. The leviathan engines now built demand to be fed with from 35 lb. to 40 lb. of coal per mile. Therefore, the fireman's task with a train which is booked to run for several hours without a stop and at a speed of over 50 miles per hour is Herculean. It would indeed be interesting to ascertain what he expends in feet-pounds of muscular energy by handling four or five tons of fuel at a stretch on the far from steady platform formed by the footplate of an engine which, for most of the run, is travelling at a speed of a mile a minute. In addition, the fireman has to attend to the water feed and lubrication. Any neglect on his part, or an error in judgment in firing heavy expresses, lands the driver in difficulties for steam supply. The idea has been mooted that engines making very long non-stop runs should carry a relief fireman, but the experience is that when three men are present on the footplate they are apt to get in each other's way, and also indulge in conversation. However, it is probable that sooner or later the fireman's duties will be lightened by the adoption of a mechanical stoking apparatus such as is being experimented with on the huge American engines.

Promotion to Driver. In course of time, the fully-trained fireman, having passed the necessary examination, commences a fresh career as a driver. His first post will be either in charge of a shunting engine, or fulfilling that which is variously known by the names of engine turner, or stabler, or, again, he may become a reliever. The duties of a reliever, or shedman, are to relieve an ordinary driver or fireman whose day's work is finished, perhaps at some distance from home, should he wire to be relieved. The duties of stabler, on the other hand, are more simple—namely, to meet engines when they return to the sheds after a trip. A stabler stables an engine—that is to say, he is the driver who shunts it from off the main track, conducts it to the coaling stage [11], turns it on the turntable, if required, and sees that it is hauled off to bed, a dead machine. The duties of both driver and fireman cease after they have dropped the fire and accompanied it to the coal stage. Engines coal for their next trip as soon as they come in, and before they are cleaned, as coaling is a dirty operation. The amount of coal which each engine receives is booked to the proper driver.

Fuel Economy. Some companies give a quarterly coal premium, in awarding which both timekeeping and good conduct are taken into consideration. Of course, anybody can save coal by losing time.

The customary procedure is to tot up the consumption of coal by each link or batch of drivers and divide the total by the number of drivers, which yields the average. The district superintendent then awards a premium to every driver whose coal consumption pans out less than the mileage rate. Where coal premiums are not given, drivers know that if they exceed the average mileage rate they will be reprimanded; but most companies, which do not give premiums quarterly, grant an engineman, on retirement, a lump sum corresponding in value to the coal he has saved during his total service. This makes a nice nest-egg for a man.

Learning the Road. Pass-firemen and shedmen are encouraged to devote their spare

time to riding on the engines of ordinary trains for the purpose of learning the road, and they are paid for doing so according to their rank. When a man claims to be acquainted with any section of road, he notifies the circumstance to the shed foreman, who examines him in respect of the gradients and signals, and, if satisfied, enters his name as qualified to drive an engine between such and such a place in the general route book, and on the route card which each engineman possesses.

The Express Train Driver. In due course the driver of a shunting engine, stabler of all and sundry engines, or shedman, is promoted to be driver of local goods, main-line goods, and passenger trains (including rail motor-cars) respectively, and ultimately the most experienced and intelligent men are selected to drive the express passenger and mail trains. Strictly speaking, there is little difference of rank or pay in the community of passenger train drivers. Needless to say, the best men are selected for the more important posts, but it does not follow that because a man drives the "crack" express of the day, say, from London to Crewe, he does the same in the reverse direction. On the contrary, he may have to work his way to town on a train, or several trains, which call at every intermediate station.


15. BREAKDOWN TRAIN

There is a prevalent misconception that the drivers of the "prides and glories" of the road are treated as superior beings; but from the financial point of view there is little in it. A few companies, like the North-Eastern, which gives a bonus to the driver of an East Coast express, single out the men in charge of the fastest passenger trains for extra emolument, but the general rule is to pay all passenger-train drivers at practically the same rate. There is a large proportion of drivers to whom promotion to the first-class division has no attraction. Such men are quite satisfied when they rule on the footplates of main-line goods and mineral trains; they have no ambition to go up another step. It is a fact, too, that the men forming the pick of the goods drivers earn more than the drivers of the fast expresses, but then their hours are considerably longer, and the work altogether is of a more fatiguing description. Goods drivers earn most in the winter time.

Enginemen and Their Engines. It has ever been the general practice with British railways that in both the passenger and main-line goods services the driver and fireman keep to the same engine for years. In America, however, the practice is "first in first out." Engines are sent out from the sheds in the order in which they come in, and when the enginemen sign on duty they take the first engine that happens to be ready. In America, again, engines are kept in steam or constantly at work for months at a time, and the footplate of each is successively occupied by fresh shifts of enginemen. There is no doubt that the American system has its advantages; the utmost is got back from the money sunk in the construction of locomotives when the latter are seldom allowed to lie idle, and although the life of an engine in such circumstances is much shorter, it is argued that it is really cheaper in the end to build an engine, work it to the scrap-heap, and replace it by another and newer model in two or three years' time, than carefully to tend engines so that they may last for more than a score of years. On the other hand, when the driver keeps to the same engine, he gets acquainted with all its peculiarities, and, therefore, can manage that engine certainly more efficiently, and often more economically, than another. The London and North-Western Railway has long worked many of its passenger engines with double shifts, and one or two other companies have recently adopted the American system where mammoth goods engines are concerned.

Ready for the Road. The driver and fireman come on duty together at the running shed an hour or so before train time. If their hour of duty begins during the night—that is, between 10 p.m. and 6 a.m. (although "night hours" vary with different companies)—they will have been called in good time at their homes by the "knockers-up" attached to the shed. The "bar-nippers" are usually employed as "knockers-up," and when bar-boys do not exist, members of the clerical staff may be entrusted with the duty, or boys who intend entering the railway service as cleaners when old enough are engaged for the purpose. Both men sign on at the time-office, and the driver, either here or at the stores, receives and hands to his fireman the keys which open the tool-boxes on the tender and the padlock round the fireirons. The driver then proceeds to the running-shed office, outside which is exhibited an array of notices which he is expected to read. Every week what is termed a "programme" is issued to the drivers. A programme is a book which tells the driver what parts of the line may be under repair, where new signals are being erected or old ones undergoing alteration, and gives him full particulars as to any altered train-working arrangements. Unless he makes himself well acquainted with the information conveyed by the programme a driver may involve himself in serious difficulties—in other words, "crimes" and "casualties"; therefore, he has always to

certify in writing that he has read and digested the programme. With the exception of those contained in the "water case," which notify the names of stations where water can only be obtained between certain hours, or, perhaps, is cut off altogether, the notices displayed on a board at the office are not so important. They usually refer to details of conduct. Drivers are warned that complaints have been made of unnecessary whistling at certain places, that ashes have been found thrown on to the point rods and signal wires, etc. Some companies make their drivers sign to having read these notices as well; but in any case failure to carry out their instructions is considered a "crime." An engine-driver makes a point of studying the contents of the "water case" first.

Stores Needed for a Trip. The driver then either goes himself, or sends his fireman to the stores, to draw oil, waste or sponge cloths, packing for glands, and the flags, fog-signals, etc., as scheduled in the rule book. Cotton-waste, for wiping down machinery, cleaning the hands, etc., has been almost entirely superseded by the use of sponge cloths, which, when dirty, are sent back to the stores to be cleaned, and so can be used over and over again. Companies which still issue waste generally allow an engineman 1 lb. a week merely for cleaning the hands. The amount of oil which the driver or fireman draws is booked to him. Several different kinds of oil are given out—namely, blended rape-oil for bearings and motion, mixed oil for axle-boxes, cylinder oil for sight feed lubricators, paraffin or colza oil for gauge and head lamps, and when a company employs the Westinghouse air brake, half a pint of special oil for the pump. As a rule, the fireman trims his own lamps, but in some large sheds this is done for him by a lamp-room staff. Not a few companies furnish their engines with destination discs, and the latter are issued from the shed stores.

Another part of the shed has now to be visited by the fireman for obtaining a supply of sand [12], which has been heated in furnaces and otherwise prepared for the road by the sand-driers. Some companies, however, make the stablers fill the engine sand-boxes.

Getting Up Steam. Driver and fireman repair to their engine, which they find awaiting them in a specified place. The engine is in thorough repair, coaled, cleaned, watered, and making steam. Some three or four hours before the enginemen are due to appear, the firebox has been cleaned and arranged by the bar-boys or other members of the shed staff to whom that job is assigned, as already described. The fire-lighters [13] follow the bar-boys, carrying fire in long shovels on their shoulders to the engine, which they insert into the firebox, and subsequently add to it about 1½ cwt. of fresh coal. One of the lighters-up takes charge of the engine until the driver arrives. He looks at it periodically on his rounds, and takes stock of what steam it is making. The time required to raise steam, say, of 160 lb. pressure from cold water will vary slightly, but about three hours is a fair average. This can easily be reduced, but it is not advisable to force the fire, as it tends towards straining plates and causing tubes and stays to leak. On the other hand, if an engine be found to be making steam too rapidly, the lighter-up lowers the damper.

The "Pit" Examination. The first act of the driver is to ascertain whether the engine is in complete repair, which is done by examining it over a pit, where it is placed in such a position that every part may be scrutinised without moving the machinery. The driver descends into the pit, and proceeds to oil all bearings, slide bars, and eccentrics, to wipe or renew trimmings if necessary, and to inspect the motion as closely as possible to discover any defects, doubtful parts being struck with a hammer, when any oil that may have lodged in a crack will ooze out and reveal the mischief. Special attention is paid to the crank axle, or "big end," as this cannot be got at while running. Sensational pictures are often published which depict drivers performing hair-breadth feats in oiling their engines when running at high speed. Some companies set their faces sternly against the practice. They wish it to be understood that sufficient time is always allowed a driver to oil his engine while at rest; and if he has to go "forward" on the road, it implies negligence on his part while in the shed.

Meantime, the fireman is cleaning the firebox, front and interior of the "cab," making up his fire to ensure a good head of steam, testing the feed injectors, looking to the tubes, and seeing that the ashpan and smoke-box [14] are clear of ashes.

Finishing Touches. On the driver returning to the footplate, the fireman and he test the gauge cocks to see if the water level is accurately shown in the glass. Afterwards the fireman prepares the coal by breaking it up to a convenient size for firing, and sprinkles it with the hose to lay the dust. The driver sees that the coal is not stacked too high, and that there is no danger of the coal, fireirons, tool-boxes, etc., falling off while running. With the huge engines and tenders now in vogue, it is no longer possible for the fireman to clamber about the tender without running the risk of being struck down when passing under a bridge or entering a tunnel. Consequently, the new pattern tenders are equipped with tool-boxes inside the tanks, and the inside of the latter are arranged so that the fuel is constantly slipping down where it is within reach of the fireman plying the shovel on the footplate.

Before leaving the shed the lubricator is filled with oil and the steam applied, so that all the water chambers may be filled up gradually without disturbing the oil; the tanks are replenished at the water crane, and as the engine steams gently out, the vacuum, compressed air, or steam brake, is practically tested.

Drivers are usually allowed from forty minutes to one hour between booking on and whistling out of the shed, and an engine generally leaves the shed for the train about half an hour before the

booked time of departure. When an engine leaves the shed punctually, the traffic department is held to blame if there be any delay in reaching the train. On coupling on to the train, the driver ascertains from the guard what number of vehicles and wheels he has behind the tender, so that he may be guided how to work his engine with due care and economy.

Express versus Goods Train Driving. The art of driving an engine is such a vast subject that it would be futile to attempt to convey any directions in a short article of this kind. We may say, however, that it is incorrect to suppose that a higher degree of skill is required to drive an express train. Every vehicle composing an express train is furnished with an automatic continuous brake, the weight behind tender is limited, the fuel is of the best, and the road is specially cleared for the express. Of course, there is an enormous sense of responsibility about the charge of an express, or, for the matter of that, every passenger train. Nevertheless, all practical enginemen will concur in the truth of the statement that goods and mineral trains which, with the increase of engine power have grown to loads of 60, 70, and sometimes 100 waggons, require more careful handling. With them the enginemen are handicapped by slack couplings and strictly limited brake power, which necessitates great finesse in negotiating the ever-varying gradients of the road, if couplings and drawbars are to be kept intact, and the train is always to be under perfect control, to pull up not only at appointed places, but also for signal checks. And the latter are of frequent occurrence in the working of goods trains.

The Driver on the Footplate. The driver's place on the footplate is in a corner, where he has the regulator, reversing gear, brake lever, and whistle under his hands, and commands as good a view as is possible through the window of the cab of the track and signals. The rule of the road prevails on British railways —trains run on the left; but it is a topsy-turvy arrangement that makes the driver occupy the coachman's place on the "off" or right-hand side. The pioneers of railways were responsible for this relic of the turnpike. Platforms and signals are on the left-hand side; the engine-driver has not to use a whip, and the guidance of his steed over the points is in other hands. Manifestly, the sensible arrangement therefore would be to place the driver on the left. One or two companies have effected this transposition. The London and North-Western long ago rearranged the engine gear for driving on the left, and the London and South-Western is following suit.

The driver is responsible for obeying the instructions of signals; his vigilance in this respect must never be relaxed, and overshooting or mistaking signals is considered about as serious an offence as a man can commit. The fireman has also to assist in keeping a look-out for signals when not otherwise engaged. Some companies make it a rule that the fireman is to stop firing when approaching an important junction or station in order to do this. However, looking into a blazing fire causes temporary blindness or colour blindness, hence there is a danger of firemen being unable to distinguish colours when necessary. On the London and South-Western Railway an important part of the footplate equipment consists of a small circular disc of purple glass, set in a metal frame. The fireman makes use of this appliance when looking into the firebox to ascertain the condition of the fire, the purple glass having the effect of neutralising the glare.

Enginemen's Links and Barracks. Drivers and firemen are arranged in what are termed *links*, meaning that certain men are kept to certain sections of the road. It is, of course, absolutely necessary that enginemen should be thoroughly familiar with the road on which they travel—the gradients, signals, sidings, stations, etc.—and this can be ensured only by restricting their field of work. The ideal, or, at any rate, simpler arrangement would be that enginemen should be able to return to their homes at the end of each trip. But this is far from being generally possible. There are what are termed "double home trips," "lodging turns," or "lodging-house jobs," which are specially favoured by certain companies, as they are supposed to yield more mileage in a given number of hours. Originally, "double home trips" were practically confined to the men working goods and mineral trains, but now the tendency undoubtedly is to extend the practice to passenger enginemen. Many companies provide splendidly equipped model lodging-houses or "barracks" at strategic points on their system for the accommodation of men who are unable to get back to their homes without working unduly long hours. The Great Eastern Company's barracks at Stratford, and those of the Midland at Kentish Town, are specially famous, and for some years past it has been the custom of the former company to supply all men who are detained therein over Christmas Day with a good dinner of old English fare. A man is paid for being in barracks 1s. 6d. in London and 1s. in the country per night. When there are no barracks each man is given a lodging allowance of 2s. 6d., and if lodged 18 hours or over 5s. is usually paid, although some companies do not allow the double rate for less than 24 hours. Some companies, however, have a list of approved lodging-houses as well, the landlords of which take in railwaymen for 1s. 6d. a night.

On "short trips," when an engine is not stabled, but waits in the yard for a few hours till the time arrives for starting on the return journey, the men may not leave the company's premises, and sometimes they may not even quit their engine without the authority of the district locomotive superintendent. The strenuous nature of modern railway business is evidenced by the fact that some companies "hustle" to the extent of employing such waiting train engines on shunting.

The End of a Trip. On returning to his own shed a driver hands over the engine to a stabler, and at once proceeds to the

office, where he makes out his returns for the completed trip. In these returns he specifies any irregularities, such as time lost, untoward occurrences, etc., and enters in a special book the character of any repairs he may consider necessary for the information of the foreman fitter. In any case, before an engine resumes work an examining fitter makes an independent investigation. The driver files the counterfoils of any water and coal tickets which he may have given to a foreign company, in the event of his having had to replenish those commodities when travelling off his own territory. At the stores his fireman hands back the sponge cloths, lamps, discs, flags, fog-signals, etc. Lastly, the two men repair to the time-office, where they hand in their keys and sign off. At the time-office they learn at what hour they are due to return to duty. Enginemen have different hours of duty nearly every day, in order to equalise the roster of turns and ensure them plenty of rest in between. The period for rest allowed between each trip is never less than nine hours.

Enginemen's Spells of Duty. Enginemen work either by the day or by mileage. Ten hours usually constitute a day's work, but with some companies it is eight hours, and with others, again, as many as eleven. Overtime is paid for, as a rule, at the rate of eight hours per day, and Sunday work reckoned at time and a half. When men work by mileage, 150 miles is almost everywhere conceded to be equivalent to a day's work on passenger trains, and 120 miles with goods, but mileage working is not often applied to the goods traffic. Thus, a Midland driver taking a passenger engine, say, from London to Nottingham and back (248 miles) receives pay for one day and six hours on the ten, but his number of trips per week are limited to four. Passenger train drivers seldom work more than four days, in the ordinary sense, per week.

Remuneration of Enginemen. The maximum pay of a passenger train driver—apart from bonuses and coal or oil premiums—is at the rate of from 7s. 6d. to 8s. per working day, while a first-class passenger fireman is remunerated with from 4s. 6d. to 5s. per working day. Enginemen are given a small annual clothing allowance, and leave with full pay for a certain number of days in each year, according to their length of service. Some companies do not pay their men while on leave. Owing to the high rents in London, enginemen residing in the metropolis are allowed a few shillings a week extra as rent money. Further, all enginemen are annually allowed one or two free passes on the railway, not only for themselves but for their wives and children as well.

Promotion from the footplate is of rather rare occurrence, but a really smart, well-educated, and trustworthy engineman may at least contemplate a field of advancement of fairly wide scope. He can rise to shed foreman or locomotive inspector, each of which posts carries with it a salary of £150 to £250 per year. The duties of an inspector are to investigate the running of engines, ride on the footplate with pass-firemen who are acting as drivers under examination, accompany royal and other high-class special trains, and report upon the trial trips of new locomotives.

Colour Blindness a Fatal Defect. In explaining the various grades of a footplate career we have not, perhaps, sufficiently emphasised the frequency and severity of the examinations for sight, both colour and distance. At every step of the ladder this test is imposed, and when a man becomes a fully-fledged driver it takes place periodically—namely, every two or three years. Few companies employ drivers over 60 years of age, and those that do so examine them annually. In any case, men over 60 are hardly ever allowed to continue in charge of express trains.

Washing Out Engine Boilers. One of the most important operations that takes place in engine sheds is "washing out" engine boilers. Every engine has its boiler washed out at least once, and more often twice, a week, when untreated water is used. The chief ingredients in boiler scale are sulphate of lime and carbonates of lime and magnesia, and a deposit of $\frac{1}{16}$th of an inch will cause an increased consumption of fuel of some 20 per cent., owing to the non-conducting character of the deposit.

The treatment is as follows: First, the smokebox [14] is cleaned of ashes, so that the plugs can be easily taken out, and no ashes find their way into the tubes. The engine is then placed over a pit, and the leaden wash-out plugs removed. Where hot water is used for cleaning, a steam pipe runs along the shed, conveying steam from a boiler to a high-pressure injector, which is equipped with flexible delivery connections of metallic hose piping and suitable nozzles for directing jets of hot water at high pressure through the different plug-holes of the boiler. Whether hot or cold, the higher the pressure of the water the better the result. Then the tubes have to be cleaned by raking them through with long, stiff wire rods, and streams of water must be directed among the tubes, stays, etc., to ensure the dislodgment of all loose pieces of scale. Finally, the glands are repacked, and the ashpan and damper put right.

The Breakdown Train. A breakdown train [15] is stabled at every running shed. It comprises tool vans, containing an assortment of jacks for lifting weights up to 40 tons, and all manner of instruments for clearing away débris and converting chaos into order. One of the vans, also, is equipped with ambulances and first-aid paraphernalia. In the centre of the train is a long eight or six wheeled truck, on which is mounted a powerful steam crane, whose boiler is always kept warm. The breakdown gang is furnished from the running-shed staff. It is divided into a regular and reserve gang. For ordinary jobs the services of the regular gang alone are requisitioned.

Continued

FORESTRY AS AN INDUSTRY

The World's Timber Supply. Its Possible Failure. Home-grown British Timber. An Industry of the Future. The Problem at Home and how it is Dealt with Abroad

By HAROLD C. LONG, B.Sc.

FORESTRY is a science which has for its ultimate object the discovery and application of such principles as will ensure the growth of the greatest amount of useful timber on a given area. The position of forestry, by which we mean here economic forestry, in Great Britain has long exercised the minds of some of our greatest and most enlightened landowners, members of Parliament, educational and commercial authorities, and many who are devoted to the subject for its own sake; but so far the results, though constituting an important beginning, are comparatively small.

In Germany, France, and some other European countries, forestry has long been treated methodically as an industrial science, and has received every attention. In fact, most continental countries are far ahead of Great Britain and Ireland in respect to the care of their wooded areas.

The splendid forest service in India may be said to have begun with the appointment, in 1856, as Superintendent of Forests in Pegu, of Dr. (now Sir) Dietrich Brandis, who eight years later was made Inspector-General of Forests for India. Since then the service has developed into a great organisation, dealing with some 200,000 square miles of forest lands, and producing a net revenue of about £600,000 per annum.

The World's Timber Supply. Some useful work is now being done in this country in instruction in forestry, and a scheme of instruction has been started in connection with the Forest of Dean. The Alice Holt Forest, in Hampshire, comprising some 1,800 acres, is also now being taken in hand by the Commissioners of Woods and Forests, and is in future to be managed on scientific lines, being also used as a demonstration area.

It is a well-established fact that many of the forest areas whence the chief supply of the British Isles is drawn are gradually becoming depleted. This is one of the most important and urgent reasons why close attention should be given to the question of providing an increased home-grown timber supply. According to M. Melard, Inspector of Forests in France, only seven countries are now able to supply large quantities of timber, these being Norway, Sweden, Finland, Canada, the United States, Austria-Hungary, and Russia. Increase of population and commercial development seriously threaten the available surplus of the three latter countries, the Norwegian supply is being dangerously reduced by a too free use of the axe, while the remaining sources of supply are quite insufficient. Forest lands have been rashly destroyed, it being forgotten—even if recognised—that no more than the annual production should be cut, and that it takes something like 80 to 100 years to produce timber fit for the sawyer. M. Melard believes, in common with some others, that a timber famine will begin before fifty years are past.

The Possibilities of the British Isles. For some years past a sum of over £25,000,000 per annum has been paid by this country for imported timber of all kinds, the major portion of which is coniferous, and, as experts agree, might be grown at home. The yearly value of the present utilised home-grown timber, chiefly used for estate purposes, cannot be even roughly estimated, but it is undoubtedly but a small fraction of our requirements, and yet we have far more than sufficient land to produce the necessary coniferous timber without a single acre going out of cultivation. It has been shown, on the highest authority, that there is in these islands a very large area of waste, heather, and rough pasture or land out of cultivation, amounting to 21,000,000 acres, a large proportion of which is suitable for profitable afforestation. According to Dr. Schlich about six to seven million acres would produce the whole of the timber (ordinary species) required which is now imported, and, with 21,000,000 acres from which to choose, the afforestation could undoubtedly be gradually accomplished.

The Waste Lands of Ireland. Although during the past thirty years there has been a steady increase in the area of woodlands in Great Britain, yet the progress is by no means rapid, while it is stated that in Ireland only 1½ per cent. of the acreage is under woods, 24 per cent. of the land area is uncultivated, and yet some 2,000,000 acres of the total waste land could be made available for afforestation. Professor Fisher, in a lecture on Forestry, given before the Royal Dublin Society, March 3rd, 1899, says: "Tenants and graziers who would oppose the planting of 2,000,000 acres of the waste lands of Ireland must be an extremely short-sighted people; the greatest of all wants in Ireland is an investment of capital of this kind, an investment which will yield an enormous return in affording labour to the people, and in supplying raw material for industries which cannot prosper without it, as well as timber for export, and for the improvement of farms and dwellings." On a different scale these words apply to Great Britain, the percentages of the woodlands to the total areas of England, Scotland, and Wales being about 5·1, 4·5, and 3·8 respectively.

Even where land of little or no value for any other purpose has been employed, the cultivation

of timber trees has brought excellent returns. On some estates in Great Britain the returns for a number of acres over a long series of years have averaged from 20s. to 30s. per annum, but the income is usually very much less, and, regular forest bookkeeping not being general, numerous statistics of cuttings are not available, while the production has not been so good as it would have been under proper management.

Examples from Other Countries. To take a German example (see Departmental Committee Report on Forestry, 1903), the average growing stock of 4,072 acres, in the Erzgebirge (Saxony), of which 93 per cent. was spruce, amounted to 2,128 cubic feet per acre in 1839, and to 3,276 cubic feet in 1893. The receipts were 48s. 4d. per acre, and the expenses 10s. 4d., the net receipts being no less than 38s. per acre per annum. Yet this very land was worth no more than 4s. per acre for agricultural or pastoral purposes.

It is maintained by Sir Herbert Maxwell that Scotch hill sheep pasture, which, as sheep pasture, yields only two or three shillings per acre, would, under correct management, yield a revenue of 37s. 6d. per acre. The same authority says (Journal of the Society of Arts, March, 1905): "It is estimated that there are 3,000,000 acres of woodlands of sorts in Great Britain and Ireland. In Belgium there are only 1,750,000 acres, yielding a return of £4,000,000 a year. At that rate British woodlands ought to yield £7,000,000 a year."

In Switzerland the Sihlwald, a forest owned by the city of Zurich, yields an annual return of about 32s. per acre. This area has been managed by the city for some hundreds of years.

In France the net annual yield from the forest area is approximately 10s. per acre.

In Great Britain the State woodlands amount to over 66,700 acres, or 2·2 per cent. of the whole area. In Germany, on the other hand, where examples of forest management form a feature of Government forests, there are some 35,000,000 acres, of which 33 per cent. belongs to the State, the whole being managed on a definite and scientific business basis for profit and instruction. In a similar way, but to a less pronounced degree, almost all civilised States own forests managed on modern lines, and, as we shall see later, many have forest schools.

An Idea for Municipalities. The planting of catchment areas by various local bodies having control over lands for water supply purposes might help considerably in the direction of afforestation. The Departmental Committee appointed by the Board of Agriculture in 1902 to inquire into and report upon British Forestry recommended that the attention of corporations and municipalities should be drawn to the advantages and profits to be derived from planting their catchment areas. It was pointed out that such planting would ultimately aid in the retention of water which fell as rain, and thus assist in regulating the water supply and in preventing floods, while at the same time forests would tend to the purification of the domestic water supply. The afforestation would naturally lead to monetary returns. The recommendations of the Committee have, with the assistance of the English and Scotch Local Government Boards, been brought to the notice of all the local authorities of England, Scotland, and Wales. The Corporation of Birmingham have allocated about 1,000 acres for plantations, to be planted principally with larch, Scots pine, and spruce. The Liverpool Corporation waterworks have about 600 acres of woodlands on a catchment area of over 20,000 acres and are still planting, having established their own nurseries in which to raise the young plants. Other local authorities are planting on a small scale or are considering the question. The water supply from wooded catchment areas is in general purer and clearer than it would otherwise be, reducing the expense of filtration, while it is not likely to silt up reservoirs.

This part of our subject would not be complete without some reference to the rating of woodlands and plantations, for the rates may bear an important relation to the afforestation of lands. Indeed, it is almost certain that some landowners have been dissuaded from establishing plantations on account of a misunderstanding of the rating.

Rates on Woodlands. The following extracts from a leaflet issued by the Board of Agriculture and Fisheries (*Leaflet No. 8, Assessments to Local Rates*) put the matter very clearly. In referring to the Rating Act, 1874, it is stated that:

"Under this enactment it is the land, and not the timber, underwood, or other produce of the land, which is made the subject of assessment. It would seem that if land used as a plantation or a wood, or for the growth of saleable underwood, is subject to common rights, it is exempt from the poor rate and other local rates. The method of estimating the gross estimated rental and rateable value of such woodlands is prescribed by Section 4 of the Act, and is as follows:

"(*a*) If the land is used only for a plantation or a wood, the value shall be estimated as if the land, instead of being a plantation or a wood, were let and occupied in its natural and unimproved state.

"(*b*) If the land is used for the growth of saleable underwood, the value shall be estimated as if the land were let for that purpose.

"(*c*) If the land is used both for a plantation or a wood and for the growth of saleable underwood, the value shall be estimated either as if the land were used only for a plantation or a wood, or as if the land were used only for the growth of the saleable underwood growing thereon, as the assessment committee may determine.

"Land of the kind described in paragraph (*a*) should be assessed as if it were divested of timber or wood of any description, and its value determined without taking into account any improvement which has been made, or of which the land might be capable. In other words, the land should be rated as if it were waste land."

The Influence of Forestry. A beneficial influence is also exercised in connection with the soil, climate, the erosion of hillsides, and protection from the force of the wind; in all these directions there can be no doubt that immense service is rendered by wooded areas. In the United States of America the necessity of forest preservation for the continued prosperity of the nation was keenly discussed and insisted upon by many authorities at the Forest Congress held at Washington in the first week of January, 1906.

Forest trees remove less food material from the soil than do agricultural crops, the major portion of the food supply being taken from the carbonic acid gas of the atmosphere [see CHEMISTRY]. For this reason, among others, forest crops may be grown continuously on the same soil over long periods of time. The system of coppice woods is, perhaps, the most exacting. Soils under forest management are also rendered more retentive of moisture, which can percolate more freely than on ordinary soils, while it is not so readily evaporated. Binding of light soils takes place under forest cover, while heavy soils are ameliorated and opened. The erosive effects of heavy rains are to a large extent obviated where there is a close canopy of trees, rain being successively retarded by crowns, stems, roots, and the covering of humus. The uses of afforestation in this connection are well seen on the mountain sides of Switzerland, France, etc., where the services rendered by woods in such positions in giving protection against avalanches and floods are invaluable. Under close canopy the soil is kept practically free from weeds.

The Climate and Forest Areas. The influence of forest areas relative to climate is often, perhaps, liable to exaggeration, the actual differences in temperature between cleared and afforested areas being in general but slight. But extensive forests undoubtedly tend to render the climate of a country more equable, the temperature of the air and soil being slightly lowered in summer and raised in winter. It has been stated that on the average of eleven German stations the July temperature of the surface soil in the forest was found to be 7° F. lower than that in the open field, whereas in December the forest soil was rather warmer than that in the open field. Forests also tend to increase precipitation of moisture.

Narrow strips of woodlands are frequently planted to afford protection not only to fields and orchards against cold and dry winds, but to exposed villages and towns. These "shelter belts," as they are termed, also serve as shelter for livestock, game, and wild birds. Such belts of trees are also utilised to break the force of high winds, and so protect the woodlands proper. Especially is this to be seen on certain open coast lines, where the wind-swept appearance of the marginal trees on the windward side of woods and forests is often well marked.

Labour and Forestry. In Great Britain the influence of forestry on labour is very small, but in some countries it is of vast importance. In the United States and Canada the lumber trade and allied industries give employment to a great number of workers. In Germany many industries depend entirely on the forests for their existence. The wages earned under forest work proper, and the industries dependent thereon, in Germany, run into many millions of pounds sterling per annum, while some 10 per cent. to 15 per cent. of the population are engaged in work connected with forestry. Among the numerous allied industries may be mentioned turning, matchmaking, wood-pulp manufacture, drum and cask hoopmaking, and the manufacture of shovels, shoes, barrows, etc. Compared with agriculture generally, forestry gives much less employment per acre, Schwappach stating ("Forestry," translation by Story and Nobbs) that in Germany arable farming employs one man for 10½ acres, while forestry requires only one man permanently employed for 308 acres. Yet more persons would be required per 1,000 acres of woodland than per 1,000 acres of hill sheep pasture, it being stated by the Departmental Committee [see Section 1] that whereas Scotch hill pastures quite capable of producing high-class timber appear to employ but one man to 1,000 acres, the same land if planted would require the services of one forester per 100 acres, quite apart from the men necessary to cut and remove ripe timber and those employed in the various trades arising from the proximity of forest lands.

Effects of Natural Agencies on Forests. In its turn, forestry is largely affected in any district by certain natural agencies which determine the character of the trees which may be planted with most advantage. It may briefly be stated here that the character of a forest area depends to a great extent on the soil and subsoil, and on aspect, elevation, and climate. The species of trees which will grow best under the same general management (after being established) will depend very much on such factors as those mentioned; the species, in fact, will differ accordingly as the land lies high or low, is open and bleak, or sheltered and mild, is porous or retentive of moisture, or is gravelly, chalky, clayey, or loamy. For example, the oak requires a fairly deep soil, while the spruce will do well on a shallow soil; the alder is suitable for very wet situations, while Scots pine occurs and flourishes on very dry soils; spruce grows at a greater elevation than almost any other of our forest trees, and poplar is found only at comparatively low altitudes. In other words, "locality"—meaning soil or climate in relation to tree growth—governs the species, and species largely determines the character of the wood or forest.

Continued

SENDING TELEGRAMS

Practical Telegraphy. How the Traffic is Handled. The Speed of the Telegraph. Sending and Receiving Messages

Continued from page 4886

By D. H. KENNEDY

Traffic Routes. Before dealing further with the instrument-room, it will be well to explain that the general system of dealing with telegraph traffic is closely analogous to that for railway passenger traffic. Small towns have lines to large towns, large towns have direct lines to all other large towns within a reasonable distance. Here it has to be remembered that as the distance increases the cost of providing and maintaining the line increases, but the sixpenny telegram is still the sixpenny telegram. Every large telegraph station is therefore a junction where messages change lines.

The route of a message is called its *circulation* and a good knowledge of circulation, and therefore, to some extent, of geography, is a desideratum for every telegraphist. It is, moreover, the special stock-in-trade of the youthful collectors.

Circuits. Now let us examine the arrangements of the *circuits* in the instrument-room. *Circuit* is the generic title given to any set of apparatus when in use for communication. In the centre, obviously for maximum accessibility, are the numerous London wires. There are eight or ten for commercial work, and three or four for receiving "News." Wires used exclusively for receiving Press messages from London are always called *news wires*.

One end of the room, let us say west of the London wires, is quite taken up with short distance local wires, while the east end is fitted up with wires to other large centres. We may call them *main cross-country* lines.

Just behind every receiving instrument there is a wire basket mounted on a pedestal rod, on which the telegraphists place the messages they receive; and again at the sending position for every town we see a narrow, deep little box, open at the top and at one end, into which the messages to be sent are frequently being placed. After this glance around, let us return to our learner. What are his sensations on coming into closer touch with the mystery of the electric telegraph?

Speed of the Telegraph. One novel and thrilling experience comes to every young telegraphist. It is the moment when he realises how complete is the annihilation of time by electricity. Even in the school he has speculated and experimented as to what was the actual interval between putting down the key and the response of the sounder; and if he *did* admit that it was too short for his powers of observation he mentally added that the distance was very short, and he resolved to repeat the experiment under other conditions when the opportunity should arise. Now it has come. He sees a telegraphist working on a circuit marked "Aberdeen." Here is a long wire, and he watches to note the interval between the Englishman's last signal and the first of the Scotchman's response. The sound of the key is still in his ears when the sounder is rattling out the reply. The learner mentally collapses. How long does it take to send a message some hundreds of miles? Merely the time necessary to signal it. He is quite stunned, and after slowly adjusting his mental conceptions he realises that telegraphy is practically instantaneous, and that the time consumed in the transmission of a message is all taken up in the handling and the formation of the signals.

He is now put in charge of a sounder circuit, working to a suburban office, and he has time to notice the methods adopted for handling the traffic so as to reduce delay to a minimum.

Messages. The messages handed in by the public are written on white forms with a big "A" in the left-hand corner. They are not always legible, and the counter clerk has to make them so. Messages received from one station to be forwarded to another are written on "B" forms—thin, yellow forms never seen by the public. Messages received at a station for delivery are written on "C" forms. These are in duplicate, and the under, or carbon, copies, go to the public.

All the writing is done with pencil, and both the "B" and the upper "C" forms are divided into five spaces per line, and one word must be written in one space, and no more. This facilitates counting, and prevents the dropping of a word.

When the telegram is handed in, the counter clerk inserts the "Code time," the "Office of Origin," and the number of words. It is immediately despatched to the instrument-room, probably by a pneumatic tube. In the instrument-room it is taken up by a collector and carried to the proper circuit. If other messages are not waiting, or in course of transmission, the telegraphist takes it up at once. He must first look at the address, and decide what the prefix will be. If it is to be delivered from the office he is working to, it will be prefixed "S." If it is to be sent on, it will be "X."

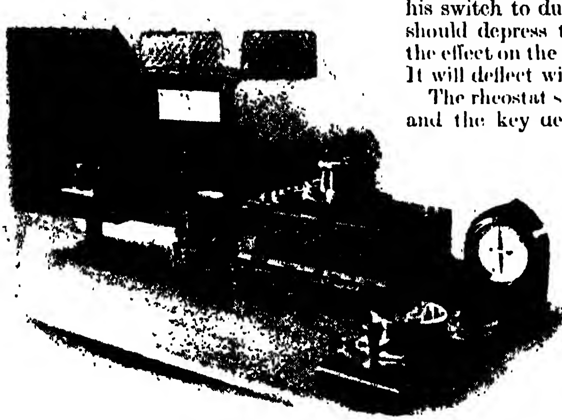
Sending a Message. When his first "A" form arrives, our new hand calls up the suburban office by signalling the prefix. In this case it will be "S," as suburban stations are never transmitting stations.

On *omnibus circuits* the station must be called by repeating the code of the station required three times, and then the code of the calling office. A *called* station replies by signalling its code, followed by the sign — — .

The sub-office signals — —. The message is then signalled in this order: Prefix, Code, Office of Origin, Number of Words, Address, Text of Message, Name from (if any), concluding with the understand signal . . . — .

The receiving telegraphist counts the words as he writes them, and immediately on the completion of the message replies by the acknowledgment signal . — . — . . The "time sent" is then inserted on the "A" form, together with the code of the distant station, and the initials of the sending clerk. The sent messages are placed on a hook under the wire basket, whence they are collected at intervals.

The School Sounder Circuit station had only two pieces of apparatus, but in actual practice a third is always present, namely a galvanometer [12]. A galvanometer is not absolutely necessary, but it is a very useful adjunct. Normally the needle remains vertical. When the key is depressed the needle should deflect to the *right*, and when signals are being sent it continues to oscillate backwards and forwards. Should it suddenly cease to do so, the inference is that the wire has become disconnected at some point. At other times, when calling fails to obtain a response from the distant office, it may be noted that the oscillation of the galvanometer needle is much more vigorous than usual. This is probably due to the fact that the insulation of the circuit has broken down at some point. In either case the telegraphist reports the fact to his superior, who will invoke the assistance of the test clerk. The complete designation of the circuit we have been dealing with is "Direct Sounder, Single Current."



10. DOUBLE-CURRENT DUPLEX CIRCUIT

The Relay. Direct sounder working is possible only on the very shortest lines. For all others it is necessary to employ relays. Relays [11] are electromagnets of special construction, sensitive to very small currents. The currents received from the distant office actuate the relay, which in turn controls the sounder. The working adjustment of the relay is made by means of the milled screw seen on the right side.

On single-current circuits the relay should be adjusted as follows. Turn the adjusting screw to the right (marking) until the sounder armature goes down, then turn back to spacing until the armature of the sounder rises. The relay is now in its most sensitive position for single-current working.

The Duplex. Next to the direct sounder, we find a circuit working to a much busier suburban office. It is of the same type, except for the fact that it has been modified to work "duplex."

In addition to the key, sounder, and galvanometer, there is a relay and a rheostat which has a movable top; also a switch for altering the arrangement from simplex to duplex, or vice versâ, as required.

The theory of the duplex system is dealt with in the electrical engineering section, but simple directions for adjusting a circuit to work duplex can be given.

Balancing a Single-current Duplex. The controlling office decides when duplex working is necessary, and instructs the other station by a service message. Both stations turn their switches from "simplex" to "duplex." The controlling office operator proceeds to "balance."

The rheostat is of the metropolitan pattern. The top, which is graduated 0, 25, 50, and so on, can be turned round so as to bring any desired figure opposite a pointer which is fixed on the side of the brass frame. Normally, the zero is at the pointer. After turning his switch to duplex, the telegraphist should depress the key, and observe the effect on the galvanometer needle. It will deflect widely to the left.

The rheostat should now be turned, and the key depressed at intervals. As the figures increase it will be found that the deflection to the left gradually decreases, and, finally, when the right point is reached, the depression of the key has no effect on the needle at all. If the rheostat be turned beyond this point the galvanometer needle will deflect to the right, the deflection steadily increasing as the figures on the rheostat increase. The highest figure on the rotating top is 225, but this can be supplemented by 300 and by 600, which are added by *withdrawing* plugs from their normal position between the brass blocks on the front of the wooden case.

The name of the unit of resistance to which these figures refer is the *ohm*. A useful mnemonic connecting the deflection of the galvanometer and the adjustment of the rheostat is given by the two words "Right, Reduce." When the controlling office has balanced, the same operation is performed at the "down" office, and working can then be commenced.

Duplex Working. Of course, two operators at each end are now necessary, and they must be fairly expert if the work is to proceed smoothly. Let us call the head office men A and Y, and the out-station men B and Z. A and B are at the keys while Y and Z are receiving. The latter are provided with long, narrow RD

slips on which they must write the "name to" of each message as received. When Y is ready, A gives — — ., and a similar signal is given B for his colleague. The senders then proceed steadily for quarter-hour periods, usually disposing of about ten messages of average length. If, say, Y fails to read a word, he informs A. A immediately signals . — . — — . —, giving the last word which Y has written. At the quarter-hour periods the names on the "R D" slips are counted, and totals exchanged, thus A will signal, "Total, ten Brown," and B thus, "Total, nine Jones." The figures refer to the number of messages received during the quarter-hour, and the name is that of the addressee of the last message. If these are correct, each gives . — . — . ., and work is then resumed for another quarter-hour. If the total be incorrect, the names on the acknowledgment slip are signalled, and the missing name found and accounted for.

The galvanometer indications should be properly understood. As already stated, when signals are being sent in only one direction, the galvanometer at the sending station remains vertical. At the receiving station it deflects to the right when a *mark* is being received, and, of course, oscillates backwards and forwards under the influence of a series of signals. Should the line become disconnected, the depression of the key causes the galvanometer needle to deflect to the left vigorously. On the other hand, vigorous deflections to the right indicate that the insulation of the circuit has failed at some point.

Main Line Circuits. Now let us look at some of the longer sounder circuits—the main cross-country lines. These are all worked on the *double-current* system. The main difference to the operator is the substitution of the light single-current key by the heavier double-current pattern [10].

The double-current key is provided with a switch marked, "Send, Receive." When working, the handle must be turned to the appropriate position. It follows that on double-current simplex circuits, once a message has been commenced, the sender cannot be interrupted by the receiver, as in single-current working. Any repetition must therefore be obtained after the completion of the message.

11. POST OFFICE STANDARD RELAY

What has been said as to galvanometer indications in the case of single-current working applies equally to the double-current system, if the difference between the two methods is kept in mind. In single-current working, the signals are made by successive impulses of current, which traverse the circuit in the same direction, and in the interval between successive signals no current is flowing. In double-current working, instead of the "no current" interval for spacing, the key is arranged to send spacing currents opposite in direction to the marking current. The observant telegraphist will note that the space deflection is to the *left* and the "mark" to the *right*. The latter, of course, is in agreement with single-current working.

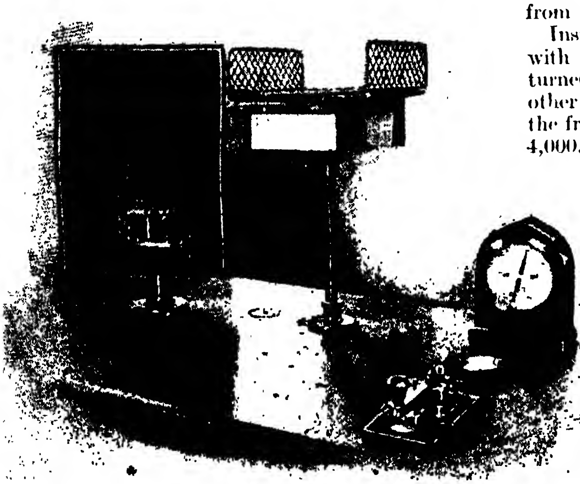
Balancing a D-C Duplex. To duplex a D-C circuit, the procedure is similar to the S-C case, with the following slight modifications. The key switches at both stations are turned to "send," and left so permanently. The galvanometer needle, instead of balancing in the centre, will take up a position about 40 divisions to the left. The "Right Reduce" rule holds good. The rheostat is larger than the metropolitan pattern. This style is called *rheostat* "*C.*" It can be adjusted to any figure, advancing from 0 by 10 to 8,430.

Instead of a rotating top, it is provided with two radial arms. One of them can be turned from 0 to 400, advancing by 40; the other from 0 to 4,000, advancing by 400. On the front there are three brass plugs marked 4,000, 20, and 10. Thus, to make up 6,670, we have:

Brass plug withdrawn from front	4,000
One radial arm turned to front	2,400
,, ,, ,, ,, ,,	240
Brass plug withdrawn from front	20
,, ,, ,, ,, ,,	10
Total	6,670

The balancing should be carried out in the methodical manner already described.

The Condenser. The large wooden box on which the rheostat



12. DIRECT SOUNDER WITH GALVANOMETER

is placed is a *condenser*. At one end there are half a dozen brass plugs. The capacity of the condenser is increased by *inserting* the brass plugs so that they connect two adjoining brass segments. The segments are marked 2, 1, ·5, ·25, and, again, 2, 1, ·5. By inserting various plugs, it is therefore possible to vary the capacity from ·25, advancing by ·25 to 7·25. The unit of capacity to which these figures refer is called the *microfarad*. To adjust the capacity, depress the D-C key, and observe if there is any effect on the sounder just at the moment of depression. If a dot be formed, the capacity must be increased till this effect disappears. If, on the other hand, no dot be formed on depressing the key, but just when it rises, then the capacity of the condenser is excessive, and must be reduced.

Fault Indications. It should be mentioned that in the event of the line becoming disconnected, the signals sent on the key at each station are given out by the sounder, but reversed, while a sudden breakdown of the insulation of the line will have the effect of causing the sounder at each station to repeat the key signals, or, in telegraphist parlance, one "gets their own marks." The great bulk of the main cross-country telegraph work in this country is done on the double-current duplex circuits, and every effort is made to provide a sufficient number of circuits between towns to carry the traffic without delay. The delay in each office is limited to ten minutes. In any cases where this is exceeded the sending telegraphist must state the cause on the back of the form.

Roundabout Routes. It is, of course, obviously deducible from this that the time taken to transmit a telegram is proportional to the number of offices through which it has to pass, and this is approximately true. From this fact, and the circulation arrangements already described, it sometimes curiously results that two places which may be quite near geographically are very badly situated telegraphically. One such case may be instanced.

Two villages on a main line of railway running east and west are four miles apart. They have no direct communication. One of them is connected to the eastern terminus of the railway, viâ one intervening office, and the other to the western terminus of the rail, viâ two transmitting offices. The main terminal offices are connected, so that a telegram from one village to the other has to pass through five transmitting offices. It need scarcely be added that such telegrams are very rare, or better arrangements would be made.

Traps for the Unwary. Frequent transmission is to be avoided, not only in order to save time, but also to avoid inaccuracies. Every effort is made by the department to secure accuracy, and mistakes are always traced home, if possible, and the misdoer punished or cautioned. But pitfalls are numerous, and the most careful clerk trips occasionally. Probably the majority of the errors are due to bad writing, but the following examples show what care is necessary to avoid errors in signalling. Compare the following pairs:

Cash —·—· ·— ··· ····
Cases —·—· ·— ··· · ···
Bad —··· ·— —··
Dead —·· · ·— —··
Satin ··· ·— — ·· —·
Sateen ··· ·— — · · —·
Calls —·—· ·— ·—·· ·—·· ···
Calais —·—· ·— ·—·· ·— ·· ···
Hall ···· ·— ·—·· ·—··
Half ···· ·— ·—·· ··—·

One example of an error due to indistinct writing may be given, because it is both true and amusing. The head of a syndicate controlling provincial music-halls was considerably mystified by a telegram from a provincial manager, asking him to "send two good twins on Monday." He was, no doubt, much relieved when, on inquiry, it transpired that "turns" had been, in transit, turned into twins, and that artistes, not infants, were wanted.

Continued

PICTURE FRAMERS. The Practical and Commercial Sides of Picture Framers. Tools and Stock. Prices and Profits

PICTURE POSTCARD DEALERS. Stock to Buy. Varieties of Picture Postcard Subjects. Stock to Avoid. Profits

PLUMBERS. The Education of the Plumber. The "Office" Plumber and the "Workshop" Plumber. Business Hints

POSTAGE-STAMP DEALERS. Philately as a Business. Building up a Stock. Stock Keeping and Selling. Commission Business

POST OFFICE SUB-AGENTS. Advantages of a Post Office Sub-agency. How to Secure the Appointment. Conditions and Remuneration

Continued from page 4423

PICTURE FRAMERS

The business of a picture framer is often conducted profitably on agency lines, all orders being sent as received to the wholesale moulding manufacturers, detailed instructions being given with the picture, carefully packed, the finished work being in due course returned ready to be handed over to the customer, or, maybe, without the glass, this being cut and fitted by the shopkeeper. The manufacturers supply numerous sets of samples of mouldings, corners, etc., each sample numbered to facilitate the selection and ordering of their goods, and marked with prices from which usual trade discounts are allowed. In this method of conducting the business little is wanted beyond samples of mouldings, mount boards, show-room display (as described below), and a tape measure.

Common "window glass" is of the same quality as that used for cheap picture frames, and the sale of window glass often proves a profitable side line to the picture framer. If the business be conducted on agency lines, this side line may still be adopted, and glass inserted into frames on receipt from the maker. The proper use of a glazier's diamond is easily acquired. A baize-covered table reserved for glass cutting prevents breakages.

Sale Shop. The sale shop may be fitted with the usual counter, under which several long shallow drawers for engravings, etc., will be useful; also some shelving for fancy goods, alternated with plain wall spaces for the display of pictures, frames, and other goods.

In convenient recesses there may be upright divisions for the storage of mouldings in the case of practical trade being chosen. Mouldings are usually in 9 ft. to 12 ft. lengths, and require the full height. In the cheaper kinds of "German" gilt mouldings, or the plain oak, both natural colour and stained, the enamelled and other cheap fancy mouldings, as well as the largely used gilt "slips"—plain flat, bevelled, or hollow moulds, usually inserted as an inner frame next to the picture—a large variety and a fair stock is generally maintained.

Fancy frames, such as ovals, rounds, Oxfords, and "swept" frames, may be bought ready-made from the wholesaler advantageously. Among this class should be set down Masonic frames containing emblems of the craft. These are in fairly regular demand.

Indispensable to a good framing business is the sale of pictures, especially of engravings, etchings, or other good reproductions of popular works of art, that may be sold at from 1s. 6d. to half-a-guinea each, with a good margin of profit. Another class of goods finding regular sale is that of artists' materials [see page 894].

A special attractiveness always attaches to the exhibition of *original* oil paintings, water-colour drawings, etc. These are generally obtainable on "sale or return" from artists of small renown, who allow a suitable commission. These, if really good work, sell better when displayed without frames, and an order for framing may be secured at the same time.

How to Take Framing Orders. It is generally found that the customer has no preconceived idea of suitable styles for framing various styles of pictures, though he has probably decided on a limit to his expenditure. The first business of the salesman is, therefore, to acquaint himself with the usual styles of framing adopted for definite classes of pictures, and, knowing these points, he should ascertain his customer's idea of price, and display the kind of frame or samples of mouldings suitable to meet the case.

For general guidance, the following leading points may be carefully noted, though individual preferences may call for occasional deviation.

Oil paintings are usually framed in gold, or best imitation gold, without any "mount," the painting coming directly under the rebate of the moulding or slip. As a rule no glass is used over oil paintings. The use of a plain slip greatly improves the effectiveness of an enriched moulding. Ornamental corners over enriched mouldings add to their rich effect, but, especially in best gold work, plain mouldings, void of such addition, are generally preferred.

Water-colour drawings are generally "mounted" either by being pasted down (by the edges only) upon a white or tinted board large enough to provide a wide margin all round, or this margin is provided by a "cut-out" mount with an opening a trifle smaller than the picture, which is then secured by touches of paste (at the corners only) on to a larger sheet of paper, and the cut-out mount laid over both to display the picture in recess. The latter is the better style, and is charged at higher rates. Various tinted mounts, from greys to pale primary tints, are occasionally more appropriate than pure white. A sheet of glass is always placed in front of water-colour drawings, as they lose much of

their colour value if exposed to air and moisture, which also rot the paper. For best qualities, a colourless glass, specially made, is obtainable.

Prints, engravings, etchings, photographs, needlework, certificates, and all such subjects, may be treated in the same manner as water-colours.

Frames. For water-colours, white enamel and gold mouldings, or enamel with a gold slip next to the mount, or plain gold of neat and light, rather than rich or heavy patterns, are in the best taste. The plain "slip" is often placed under the glass, preventing contact between the glass and the picture.

For photographs, etchings, engravings, and other black-and-white or monotint pictures, a plain oak frame, polished or unpolished, natural colour or stained, made up with a plain gold slip under the glass, maintains the quiet dignity of the picture as a contrast to the gaiety of highly-coloured work, which may be enhanced by more elaborate framing.

"Swept" frames are peculiarly adapted to ancestral portraits, old engravings, and pictures by old masters. These are the old-fashioned heavy gold frames in which ornate corners are joined by scrolled curves.

Best Gold Frames. These, being executed with real gold leaf laid perfectly level and finished with either matt or burnished surface, by various methods requiring apprenticeship or long practice, may with advantage be sub-let to expert gilders who work for the trade.

If the beginner wishes to acquire the necessary proficiency to execute his own gilding, he must prepare for it by special practice, in which Scott-Mitchell's book on "Practical Gilding, Bronzing, and Lacquering," may be of service. (Price 3s. nett. Trade Papers Publishing Co., Ltd.)

Mounts. Wide margins may redeem a small picture from appearing commonplace.

In mounting prints, etchings, etc., sometimes it is desired to display the "title" (printed on the lower margin of the picture), though some object to this because the first proofs in good works of art contain no descriptive title. The customer's preference should be ascertained beforehand on this point, and, if required, a small opening may be cut in the mount, carefully adjusted to the position of the title. Rounded or pointed ends to this opening add to the neatness of finish.

When taking orders for framing with "mounts," it is economical to adhere to definite fixed sizes in which the mounting boards are usually supplied. These are as follows (in inches): 10 × 8, 12 × 10, 15 × 11, 19 × 12, 22 × 16, 24 × 9½, 24 × 19, 26½ × 16½, 26½ × 19½, 30 × 11, 30 × 22, 33½ × 16½, 39½ × 26½, 40 × 30. Comparatively few orders will come for larger sizes than 30 × 22. When cutting out mounts for large-sized pictures, the panel cut out from the board should be kept clean for probable use in mounting smaller work.

Measuring. The measure of the mount when ready for framing is called the "glass measure," and that is the measure always recorded as the *size to work to* in making the frame. When a gold slip is used, this is made first and the larger frame fitted round. Hence, in measuring for frame moulding, due allowance must be made for these points, which in some cases may mean considerably increased cost, especially in case of English gold frames. A safe method when calculating the value of frame moulding required is to add four times the width of the moulding to the total of glass measurement. The extreme outside of the frame is the measurement to be charged for, because the irredeemable waste of corners cut away cannot be overlooked. Also note that the usual lengths of picture mouldings (from 9 ft. to 12 ft.) will often be just too short or too long to "cut up" without waste pieces at the ends, which may be of no further use. The latter point may sometimes affect the recommendations of the salesman as to size of frame to adopt, especially in cheap kinds of work. Oval, circular, swept, Masonic, and Oxford frames are best ordered to given sizes from the wholesaler.

Prices. A reliable method of pricing is to total up the prime cost of materials, such as mouldings, mounts, glass, eyelets, etc. (allowing for necessary waste), and multiply that total by three, which will be, as a rule, the fair selling price, including average cost of making up and a reasonable profit of 25 to 30 per cent. This system is specially applicable when "German" mouldings are used. It may be called into service for real English gold work by adding the price of gilding to the former total, at the rates given below.

Oil gilding in genuine English gold leaf is usually charged 9d. per foot run for first 1-in. girth or part of an inch, and 6d. per foot run for each additional inch girth. Matt and burnish gilding is charged double the rates of oil gilding. Cost of gilding, if put out to the wholesaler or to the expert who works for the trade, will be from three-fourths to two-thirds the prices named; while if the work be done in the framer's own workshop by competent employees, the cost may sometimes not exceed one-half the price chargeable. But, as already mentioned, the work of the gilder is a distinct trade, and unless a competent workman be employed, or very considerable practice be obtained on correct lines, there may be sufficient waste of the precious metal to create a loss instead of a profit.

Repairs to old frames before regilding usually constitute an extra charge. They may require the services of a practical frame-maker, though the aspirant may learn the customary methods from Scott-Mitchell's book on gilding already mentioned.

Workshop. Whenever convenient, it will be found most profitable to make frames on one's own premises. The mouldings are all made with a rebate ready to receive the picture, etc. To describe the making of an ordinary frame in brief would be:

"Cut the necessary four lengths (two exact pairs) from the mouldings, each length with its ends cut at an angle of exactly 45 deg., without chipping the surface or other damage, and fasten the ends together with glue, adding screws or brads for permanent security. Insert the

picture (with glass and mount when required), and make up the back with back boards of thin cut pine, covered with brown paper carefully pasted over all to the edge of the frame. Panelled backs replace the thin back boards for best work."

Tools. To facilitate this apparently simple process there are scores of mechanical contrivances without which no business can be done profitably. They are inexpensive, and from the extensive variety offered to the trade the following list is compiled with the double object of economy and efficiency:

Mitre Block. This is a large tablet of wood, surmounted by a smaller block of hardwood, fixed so as to leave a margin on the tablet on which to lay the mouldings for cutting into required lengths. A mitre block costs from 5s. upwards.

Shooting Board. A similarly-built tablet for the convenient use of a plane to make the mitred ends perfect before gluing them together; value, 5s. upwards. Some tool-makers supply this and the preceding tool combined; value, 9s. upwards.

Mitre Plane. A smoothing plane specially designed for "shooting" the mitres by sliding in a rebate on the "shooting block"; value, 6s 6d. upwards.

Tenon Saw. A fine steel saw, specially gauged for sawing picture mouldings; value, 5s. 6d. upwards.

Cramping Machine. A table with long arms crossing it diagonally, X-shaped over the top, in which slide four corner grippers, controlled by a handled screw. The frame is placed on this cross immediately after gluing up the corners before the glue is set. By turning the screw handle the four corner grippers close in upon the frame simultaneously, and by uniform pressure in all directions secure the accuracy of the square. The glue then cements the corners securely in their true positions, and before releasing the cramps each corner may be permanently fixed by driving screws or brads, care being taken to keep clear of the face of the mouldings. These machines are now almost indispensable to the trade, and are made in various sizes. A suitable size for general use is known as No. 2 (Lawson's patent), and will cramp any size of frame from 4 in. by 3 in. up to 4 ft. by 3 ft; value, £2 6s. Extended sizes are obtainable, but seldom required.

Two Wood-cutting Chisels. For trimming; value, 2s.

Oilstone. For sharpening tools; value, 2s. 6d.

Oil-can. Value, 6d.

Cutting Board. For laying mounting boards upon while cutting out. This has to be of well-seasoned wood, well bound, to prevent warping, and must be large enough for large-sized mounting boards. A most useful size and quality is 36 in. by 30 in.; value, 10s.

Steel Straightedge. Bevelled and rule-marked, for mount cutting, 3 ft. long; value, 6s. 6d.

Mount-cutting Knife. Value, 2s. 6d.

T-square. Adapted for glass cutting and for mount marking, 3 ft. long; value, 2s. 6d.

Glazier's Diamond. For glass cutting; 8s. 6d.

Glass Pliers. For blunting corners of glass squares, and for snapping off narrow strips after cutting; value, 3s.

Glue-pot. For melting glue; value, 3s.

Glue-brush. Value, 6d.

Paste-brush. Value, 6d.

Hammer, Panel-pins (fine nails), Military Brads, Screws (fine and light), Screw-eyes, Nail-punch, Bradawls (various sizes), and usual tool-boxes.

From the above list it will be seen that a moderate workshop outfit can be obtained for less than £7.

There are other labour-saving contrivances, such as mitre-cutting machines, mechanical mount-cutters (42s. and 24s. respectively), and heavier machinery for large factories, to be power-driven, at correspondingly higher prices; but the list enumerated above will fulfil all workshop requirements of a moderately good retail business.

Stock of Mouldings. It will generally be found wise to stock a variety with small quantities, say, two or four lengths of each kind, according to cost, to start with, as these goods are easy to replace. German mouldings are cheap and good, ranging from 3d. (½-in. slips, common quality) to 5s. per length of 9 ft., the latter for wide and deep mouldings of best quality, the average cost for most saleable sizes being from 1s. 6d. to 2s. per length. Mouldings "in the white," ready for the gilder's art, may, with advantage, be stocked to a limited extent at first if making up own frames, and sent to the gilder afterwards. These are of better quality than the German mouldings, and cost slightly more. Glass, thin cut pine for back boards, and stout brown paper, complete the needs of the framer.

Capital Required. To a sum of £7 for workshop outfit, add £10 for mouldings, £5 for glass, back boards, and sundries, £10 for pictures and fancy goods to start the show-room display (see periodical market lists), and a total of £32 is reached. Allowing a sum of £8 for show-room and window fixtures, sign board, etc., if the beginner starts with the comparatively small capital of £50, a working margin of £10 would be left in hand, which would be sufficient if prospects were good.

PICTURE POSTCARD DEALERS

Like its near relative the Christmas card, the picture postcard originated on the Continent, and from very small beginnings rapidly developed into a flourishing business long ere it took hold of the British public. But to-day there is not a town or hamlet in the United Kingdom where the picture postcard has not penetrated.

Local views are, of course, the primary subjects, stock of which it is safe always to keep; but every conceivable sphere has been exploited to provide a novelty, and not a day passes without some new design being produced. It goes without saying that there has been a steady and distinct advance in the artistic quality of the work produced.

Stock to Buy. Although in every town of any considerable size there are one or two shops where nothing but cards are sold, the sale of picture postcards is not confined to any trade, but may be undertaken by anyone who has a shop or a window to show them, and no special training is necessary for the sale of them. The terms on which the cards are bought are advantageous to the retailer. As a rule, he can purchase good saleable cards at a discount of 33⅓ per cent., and if in good quantities, at 50 per cent. The most popular selling lines are the penny and twopenny, and these can be bought—and first-class work they are—at 8s. and 16s. a gross. Every now and again, however, the dealer will have from some publisher the offer of a surplus stock of cards which have fallen flat on the market, and he may be tempted by the apparently exceptional value offered - sometimes a tenth of their supposed value. He may be induced to buy, and may do well with them, even supposing he may fail to clear them. But the chances are that he will very soon find that the transaction has resulted chiefly in the transference of stock from the cellars of the publishers to the shelves of the retailer, who, as a rule, has sufficient remainders of his own to satisfy the most ambitious.

Local Views. At one time it was a very good idea to get up a set of local view cards, confined entirely to one dealer. These, of course, cost more than if they had been selected from the stock of the wholesaler, as the retailer had the photographs to provide, or pay for, and, as a rule, had to take a fairly large quantity. Now, it would be a mistake to do this. The quantity necessary to secure the restriction is generally too large for most districts; and so many houses have views of nearly all the principal places of interest in the neighbourhood that a much better variety can be obtained, and at a much lower price, by simply selecting from stock. It is not necessary to order large quantities of any single card—you can always send repeat orders, and new views can be added as they come out. Quite a good trade can be done by arrangement with printers, whereby customers' own photographs for private circulation can be printed on postcards. This trade is fairly profitable, and has the special recommendation that there are no "remainders" or bad stock. Again, if the dealer be himself a "knight of the camera"—and who is not, nowadays?—he can utilise his accomplishment in some interesting local event, print off his cards, and sell them while the incident is still fresh in the memories of his customers. There is no need to make suggestions here, as each district will readily supply its own incidents.

Stock to Avoid. The picture postcard has come to stay. It may readily be added as a valuable adjunct to almost any business, especially to that of the fancy stationer, who will find in it more than a compensation for the decrease in the sale of notepaper. For there is no doubt that since the advent of the picture postcard letter writing has to a large extent gone out of fashion.

Now let us give a word of warning. In order to retain and develop this business, which is at once a source of pleasure to the customer and of profit as well as pleasure to the seller, all dealers should beware of allowing anything vulgar, indecent, or suggestive of indecency, to creep into stock. There have been and there are such cards on the market, and there are dealers vile enough to engage in the traffic. The British public is clean minded, and will on no account tolerate this. Nothing will more quickly kill this business than the publication and sale of such filth. The Stationery Trades Association is aware of this fact, and, we are glad to note, has taken up a strong position in regard to it. It rests with dealers themselves to be vigilant in stamping it out, and they will find that they have, as a rule, loyal allies in the magistrates and police throughout the country.

PLUMBERS

The business of a plumber is one in which scientific knowledge must be wedded to mechanical skill. The days when mechanical skill was all or nearly all of the plumber's qualification are passing swiftly. Mechanical and physical science, the principles of sanitation, ventilation, and water supply, and more than a smattering of chemistry, are elevating the "trade" into a profession, and the increasing appreciation of the requirements of sanitary science is bringing to the expert plumber some of the recognition which is his due.

Apprenticeship. Apprenticeship formerly lasted seven years, but for some time there has been a tendency towards its curtailment. Five years is now not uncommon. When apprenticeship in the workshop is united to technical and scientific instruction in the evening, the present-day five years' apprentice emerges much better equipped than the former seven years' man. Premiums are common in the trade, but not universal. They vary from £5 to £50, and the wages from 2s. 6d. to 5s. per week during the first year to from 10s. 6d. to 20s. during the last year.

Associations of Plumbers. For some years two bodies have been striving to lead the members of the plumbing craft in Great Britain—the Worshipful Company of Plumbers in London, and the National Association of Plumbers with headquarters in Hull. The former body are to be congratulated upon being one of the few London livery companies who are now taking an interest in the craft from which they derived their origin; but on account of the manner in which they have sought to secure ruling powers over the trade their efforts have been regarded with cold neutrality by sanitary and other representative bodies who might have furthered their aims. Opposition also has been strong, and the tide of battle seems to be favouring the National Association of Master Plumbers, composed of practical men who know what they want, and who are more likely to lead the plumbing trade into professional recognition. The Association

was formed in 1895, and registered two years later. The objects of the original society, briefly stated, are:

(a) To improve the status of the trade by schemes of education for employers, operatives, and apprentices, and to act in conjunction with any or all of the existing educational authorities for the purpose.

(b) To establish an official organisation having authority to represent the craft of plumbing, and managed by persons *bona fide* in the trade, to act on behalf of the trade in its relation to the Government, county councils, municipal and other local authorities, associations of architects, and all other institutions having any connection with the plumbing trade.

(c) To organise and to bring into existence local associations or branches of the national body for the purpose of dealing more readily with matters of a purely local character, and generally to create and maintain a brotherhood and community of good fellowship amongst all engaged in the trade.

The association is being reconstructed as we write, and is acquiring additional powers. It is proposed to give it a new title—the Institute of Plumbers—and to raise it to the dignity enjoyed by the Surveyors' Institute, the Institution of Civil Engineers, and the Sanitary Institution. The Board of Trade is, at the moment, considering the proposed constitution.

The new institute will have power to deal with examinations in plumbing, but in the meantime it co-operates with other associations in a joint examination scheme, syllabus of which is appended.

Technical Instruction. Instruction in plumbers' work may be had at technical schools and institutions throughout the kingdom, and the fees are merely nominal. Examinations are held annually at the schools where instruction is imparted, and certificate awards are made by the examiners of the City and Guilds of London Institute (Department of Technology), South Kensington.

Students who compete successfully in the written examination receive a certificate in the "Principles of Plumbing." Those who pass in both the written and the practical sections are awarded a certificate for "Plumber's Work." Students are recommended to attend a two years' course of instruction before presenting themselves for the preliminary examination, and those who consider themselves competent may enter for the ordinary grade examination without having attempted the more elementary part.

Registered Plumbers. Examination by the Plumbers' Company secures the qualification of "registered plumber," but this City company has decided to cease holding examinations. Most of the master plumbers who hold the certificate of registration have, however, secured it by "testimonial" and not by examination. It is probable that the examination of the City and Guilds of London Institute, mentioned above, will entitle to the degree—if it may be called so—of registered plumber. It may be added that the wearer of the title "registered plumber" possesses no specific privileges above his fellow who has not earned the right to the title. The title which may be assumed by plumbers who shall have passed the examination of the new Institute of Plumbers will be *member* or *associate* or *certificated* plumber.

EXAMINATION IN PLUMBING BY CITY AND GUILDS OF LONDON INSTITUTE.

PRELIMINARY EXAMINATION.

[Annually, in April. Fee, 1s.]

The preliminary examination is written only.

1. Workshop arithmetic, geometry, and drawing.
2. Elementary science for plumbers.
3. Alloys, solders, etc.
4. Workshop appliances and the principles of their action.

ORDINARY GRADE.

[Annually, in April. Fee, 1s. 6d.]

Written and practical.

1. Elementary science for plumbers.
2. Drawing for plumbers.
3. Properties and uses of materials.
4. Mechanical appliances and the principles of their action.
5. External roof work.
6. Hot water apparatus.
7. Sanitary appliances in common use, and the principles of their action.
8. Drainage.
9. Practical test in marking out and cutting off sheet lead; in bending pipes of from 1¼ in. to 3 in. in diameter; in joining lead pipes with wiped soldered joints, and in bossing lead.

HONOURS GRADE.

[Annually, in May. Fee, 5s. If the written examination only is taken, the fee is 1s. 6d.]

Written and practical.

1. *Water.* Qualities and properties of water from deep wells, shallow wells, springs, and other sources, water storage, filtration, general distribution, and arrangement of services in buildings, flow through pipes, loss of head, and retardation by bends and branch pipes.

2. *Plans and Specifications.* Preparation of plans and specifications for general plumbers' work and house drain construction, in compliance with the local sanitary authorities' by-laws and regulations.

3. *External Roof Work.* Details of covering domical and turret roofs, finials, Mansard curbs, making plain and ornamental rain-water pipes and heads, lead burning.

4. *The Warming of Buildings.* Heating by hot water and steam, high and low pressure, and hot air. Amount of heating surface required for rooms and buildings of different sizes. Principles of heating water for domestic use by steam heaters, etc.

5. *Sanitary Appliances.* Their arrangement and position in dwelling-houses, hospitals, and public buildings. Principles of construction. Methods of automatically removing grease from traps, and flushing public conveniences and drains. Entry of tidal, storm, and other waters into basements of buildings, and the prevention of same.

6. *Ventilation.* Ventilating apparatus for apartments in dwelling-houses and public buildings in which sanitary fittings are fixed. Systems of mechanical ventilation, and methods for washing and purifying air, ventilating stoves, etc.

7. *Drainage.* Principles and construction of house drainage with disconnecting and inspection chambers, gullies, interceptors, and other traps. Ventilation of drains and soil-pipes, etc. Drain testing by water, smoke, chemical substances, and air pressure. Simple methods of sewage disposal for isolated country houses.

8. *Practical Test.* Bending lead pipes of all sizes; joining them by wiped soldered joints without the use of lamp or gas-jet, or by lead burning, in such positions as would occur in practice; bossing lead to a given form, and any other piece of plumbing work. Practical tests are held locally only if five candidates enter. If less than five enter, special arrangements are made.

The Plumber in Business. The business of a plumber is not one demanding a large capital, unless it be attempted on an ambitious scale and with large stock of material. Nowadays, many plumbers' businesses are run from an office only, without workshops or warehouse accommodation. It is becoming common to do all plumber work on or in the buildings in course of construction or under repair, and the plumber merely draws upon the manufacturer or plumber's merchant for supplies as he requires them, and returns any material left over, the workmen employed providing their own manual tools.

A business run on these lines is possible only in a city or very large town. The country and provincial plumber must have his shop fitted with benches and some shop tools. Even the city plumber who does a jobbing trade must also have his shop and warehouse.

The jobbing trade, being the most remunerative, should be cultivated. The price got for labour represents a large profit upon its cost. The wages of workmen vary from 6d. per hour in some country districts to 11d. per hour in London, and their hours from 47 in London to 56½ in some country towns. The price charged for labour, even in towns on the lowest scale, is seldom less than 10d. an hour, and in London a charge of 1s. 6d. an hour is not uncommon. The profits on material are also good from 33⅓ to 100 per cent. on cost prices—when the work is ordinary jobbing, so that the plumber with even only half a dozen men in his employ may make a very good thing out of his business.

Estimate Work. New work is seldom secured otherwise than by competitive tender, and in most districts such work is cut down in price until profits are bare or non-existent. The new man must take a hand in this game of "beggar-my-neighbour" if he would establish himself. He has the advantage that in his eagerness to make a business he will work hard himself, and exercise a stricter supervision than his competitor claiming earlier establishment. Thus, he may be able to make a profit when the firm in a larger way could not come out of the job with a profit. On the other hand, he may be under the disadvantage of not being familiar with the practice of the architect or clerk of works, who may put him to expense by the arbitrary enforcement of useless clauses in the specification.

A non-remunerative job may often be made to pay by the *extras*, and a knowledge of the habits of an architect in adhering to the details of his specification is worth having when tendering for work under his charge.

Allies of Plumbing Proper. The term *plumbing* has come to be wider in its scope than the mere working in lead, and house sanitary fittings, which was the origin of the name. It is usually allied to gas fitting, and hot water fitting, and sometimes to the installation of hydraulic plant, to the work of an electrician, and to tinsmithing. It is probable that from the various tradesmen engaged upon the installation of sanitary, ventilating, and heating apparatus, a new profession—that of the domestic engineer [see page 2218]—will be evolved.

The Merchant Side of the Business. Development of the merchant side of the plumber's trade is usually wise, particularly since the trade in incandescent gas fittings began to assume its present large dimensions. The plumber who keeps no front shop neglects an important means of feeding the working department, and allows to go to other shopkeepers trade which he might easily have. In such things as sanitary fittings, the best method of display is to have a showroom arranged with samples of the best style of lavatory basins, baths, and closets, with water supply connected up. These samples should meet the demands of modern ideas on the subject of sanitation. The sum of £50 plus the labour would pay for fitting up a very fine show-room, say, two baths—one of the shower type—three or four lavatory basins, a similar number of closets, and perhaps a foot bath. A tiled floor, and walls of tiles, or of "Emdeca," will add to the expense, but may be worth it, and will make a handsome sanitary show-room sure to attract custom. The tile fitting can be done in his slack hours by any workman sufficiently expert. From the roof should be suspended some samples of gas pendants, and brackets should be mounted on the walls. It is unnecessary to carry heavy stocks of sanitary and gas fittings.

Stock of cisterns, faucets, unions, and plumber's brass work must, of course, be held in a fully equipped plumber's business. In the sale shop and windows the public should be shown the latest things in gas lighting. Excellent use is sometimes made of tiny models of sanitary fittings in the window. The competition of the gas companies—municipal or otherwise—may qualify the wisdom of stocking gas fittings upon a heavy scale, but gas mantles and other accessories of incandescent gas lighting can be sold freely in spite of all the competition which companies and corporations can bring.

Buying. The plumber who keeps stock of plumbing materials can usually do better in his purchases than the mere "office" plumber. He is not tied to the merchant so much, and can draw many of his supplies from the manufacturers, thereby securing keener prices. The terms offered by both merchants and manufacturers differ. When the standing of the plumber is known to be good, he can usually get three months' credit, or should he pay monthly or at shorter date—always an advisable course when it is possible—he will secure better terms.

Gas Cookery. A department which at one time gave promise of developing to the benefit of the plumber is that of gas cooking and heating stoves, but the policy of hiring these appliances and of fitting them free of charge, which has been adopted by gas service companies, has killed whatever promise there was. Therefore, except in a few exceptionally favoured districts, the plumber is wise in leaving this department severely alone, reserving his energy for matters more likely to be remunerative.

Acetylene Plant. The scale and installation of acetylene lighting plants offer scope for the enterprising plumber in the provinces. The work needs a good knowledge of the principles of acetylene generation apparatus and supreme care in its fitting. The man who makes himself an authority on the subject has at command a means of making good profits. There is not, for the work, the competition which prevails elsewhere. The prospect of securing business from the owners of country mansions and farmhouses is very good if energetic efforts be made to obtain it. These efforts may be made in the distribution of circulars, in personal visits, and by the exhibition of acetylene apparatus at local exhibitions. The purchaser of a plant becomes a constant customer for carbide of calcium, the storing of which, however, requires a knowledge of the legal provisions governing its sale.

Work for Public Bodies. Some municipalities, large institutions, and local educational authorities offer the work of keeping their property in sanitary repair for public tender. To estimate for such a work is a pure gamble. A severe winter may involve in a heavy loss the plumber who secures it, and a favourable year may enable him to come out of the contract fairly well. The wisdom of entering the competition for such work depends upon several conditions. If the plumber be a man of very small capital, he will do well to refuse to look at it. There may be circumstances when it is politic to risk the loss, but even this is questionable.

Textbooks. In recommending textbooks for plumbing students, we cannot do better than enumerate the works of reference suggested by the Department of Technology of the City and Guilds of London Institute: "The Plumber and Sanitary Houses," by Hellyer (Batsford. 12s. 6d.); "Standard Practical Plumbing," by Davies (Spon. Vol. i., 7s. 6d.; Vol. ii., 10s 6d.; Vol. iii., 5s.); "Building Construction," by Mitchell (Batsford. 5s. 6d.); "Treatise on Warming Buildings," by Hood (Spon. 15s.); "Hydraulics," by Box (Spon. 5s.); "Hot Water Supply," by Dye (Spon. 3s.); "Pump Construction," by Bjorling (Spon. 5s.); "Plumbing," by Hellyer (G. Bell & Sons. 5s.); "Domestic Sanitary Drainage," by Maguire (Kegan Paul. 12s.); "Plumbing Practice," by Clarke (Batsford. 5s.); "Metal Plate Work," by Millis (Spon. 9s.); "Hydrostatics and Pneumatics," by Magnus (Longman. 1s. 6d.); "External Plumbing Work," (1896), by J. Hart (Scott, Greenwood & Co. 7s. 6d.); "Water Supply," by Thresh (Rebman. 7s. 6d.); "Plumbing and Sanitation," by Davis & Dye (Spon, 55s.); "Hints to Plumbers," by Hart (Scott, Greenwood. 7s. 6d.); "Pumps," by J. W. Clark (Batsford. 3s. 6d.); "Hydraulic Rams," by J. W. Clark (Batsford. 2s.).

POSTAGE-STAMP DEALERS

In stamp dealing it is practically impossible to know every stamp issued, but a general acquaintance with the postal emissions of all countries is a necessity. It may be assumed that a young man desiring to enter the stamp trade has had his thoughts turned in that direction by a familiarity with stamp collecting as a hobby. Knowledge gained from forming a collection of his own will stand him in good stead in the business. If the prospective dealer has not this experience of stamps, he will have to start collecting judiciously, bearing in mind that the collection he is forming will ultimately become his stock, and ought to yield a substantial interest on the money invested in it. He will get his elementary knowledge from the various primers sold, along with which he must study the priced catalogues issued by other dealers, and watch the fluctuations in the prices, not so much of individual stamps as of classes of stamps.

Assistants in Small Shops. If the beginner has a moderate knowledge of stamps, a position might be obtained as an assistant in an established firm. These openings in the highest class firms are extremely rare, however, so it is likely he will have to be content with serving a small dealer at a remuneration of 20s. to 30s. a week in order to gain experience in the handling of stamps. A warning may be urged here that he should not allow himself to be led away by the lack of business method displayed by many small dealers. He had better spend his evenings after work in studying bookkeeping, and the systems of card indexing, advertisement writing, and, where possible, in attending displays of fine collections at the meetings of the local philatelic societies.

Shop or Office? In England, most of the stamp businesses have shop premises, although a very large portion of their work is done by correspondence. A few highly successful ones are conducted postally from private addresses. In America, the businesses are mostly carried on from offices upstairs—many of them necessitating a journey in an "express elevator" to reach them. One Boston firm has met with considerable success in employing a travelling salesman, who visits private collectors, customers of the firm, all over the United States and Canada, taking with him selections of the finest things in stock at the time.

The Cheap Packet and Approval Sheet Trade. There are three distinct classes of stamp trade on which one may embark, according to capital and knowledge of the subject on the part of the intending dealer. The trade in packets and low-priced approval sheets, or the "boy trade," can be started with a very small amount of stamp knowledge, and only a few pounds of capital. The profits are high, but the business is not great. Doing this class of business postally from one's home address, a capital of £10 would suffice for a start. One main feature of this business is that the packets—which must contain good value—are the chief means of introducing approval sheet business.

Capital and Profits. In this class of trade a third of the £10 capital might go to the purchase of stamps for retailing at ½d. to 1s., and a quantity of cheaper stamps for enclosing in packets. Another third should go towards

supplying the dealer with a stock of ruled and spaced approval sheets, small envelopes for packets, gummed hinges for mounting the stamps on the sheets, and a few other trifling requisites. A portion of the remaining third should be devoted to one or two small advertisements in papers which reach the class of customers whom the dealer is trying to interest.

Stamps for retailing at ½d. on cheap approval sheets may be had from wholesalers at from 4d. to as much as 1s. 6d. per 100. Stamps to sell at 1d. and 2d. each are about double and treble respectively in wholesale price. The wholesale rate on stamps for retailing above 3d. and 4d. each do not yield quite the same profit, but they represent better returns. The profit on this trade should work out at not less than 40 per cent.

The Small Shopkeeper. To start a small shop entails a considerably larger capital. It could be done with from £50 to £75. The nucleus of the stock of stamps is generally the collection formed by the proprietor before entering the trade, a portion of the monetary capital going to purchase small wholesale lots for making up into packets and for making a window display. A stock of accessories in the way of albums, handbooks on stamp collecting, tweezers for handling stamps, gummed hinges for mounting specimens, and other goods will be required. Select a small shop on the shady side of the street if possible, as the colours of some stamps—violets, purples, blues, etc.—fade quickly if exposed to excessive light, and much good stock may be spoiled. Another important thing to consider in taking a shop is to get it in a good business quarter—where much foreign business is conducted—so that you will get opportunities of buying good stock cheap and first hand. Clerks and business men will often look in with stamps for sale, and in this way you may pick up some good things and sell them to other dealers, or keep them in stock for your own customers. Small dealers often get rare stamps in this way for which they have no customers, so they sell them to a dealer who has customers for them. It pays the small dealer to get a quick turnover by selling in this way, and the man with the customer for the rarities can command a very high profit, as much as 400 to 500 per cent. in many cases.

In the stamp trade successful buying is as important as successful selling. It is more difficult to get good stamps than it is to sell them. A dealer should get into touch with correspondents all over the world who will supply him with stamps direct. Advertisements in papers with foreign circulations will help to form such a connection.

Have a Speciality. The small shopkeeper will find it worth his while to have a speciality. That is to say, that while not neglecting to keep a representative general stock of the world's stamps (that is, as representative as his capital will allow), he should also make a special feature of one country or small group of countries. He should thoroughly master the study of the stamps of the country or group selected, and stock them well. In this way he will come into contact with customers who are forming specialised collections of that country, and his sales to these collectors should be considerable.

The Question of Prices. With regard to prices, there are certain priced catalogues of dealers' stocks issued annually, or at slightly longer intervals, which have come to be recognised as reflecting the approximate values of nearly every stamp known. These catalogues are extensive and valuable works of reference, and are indispensable to every dealer. The catalogues are published by big firms with heavy expenses for large and centrally-situated shops and highly-salaried staffs, and these have to be paid for by the sale of the stamps at good prices. Proprietors of small shops, with but trifling expense for paid assistance, can afford to sell a very large number of stamps at less than catalogue prices. The small dealer will have to decide what discount he can allow off stamps according to the prices he has to pay for them in the first place. New issues, and current unused stamps, cannot be sold much, if at all, under catalogue quotations, as there is usually only 10 per cent. above face value charged upon them, and the cost of importation and handling has to be deducted from this 10 per cent.

Stamps to Stock. In Great Britain, the class of stamps which must chiefly be stocked by the small dealer are old English stamps and British Colonials. Probably about 75 per cent. of a small dealer's customers will be collectors of British Colonial stamps only. Unfortunately, the old trade in foreign stamps (as distinct from Colonial issues) is not as it used to be. An American dealer will have to stock both the United States (with Colonial possessions) and British Colonies. Hawaii, Cuba, Porto Rico, Philippines, Guam, Panama, and South American States are in good demand in the United States, as also are the issues of the Haytian and Dominican Republics.

The Importance of Condition. An all-important point for the dealer with a medium-class trade is to see to the condition of his stamps. A thorough philatelist insists on absolute perfection in every stamp purchased. The colour must not have been faded or the paper stained. No particle of the perforated edge may be missing, and if the stamp has been through the post, the fastidious customer will want it only if it has a light or clearly impressed postmark, and not an inky smudge. If unused, the gum on the back should be in its original untouched state. There is little or no sale for damaged or soiled stamps.

The High-class Business. To conduct a high-class stamp business a large capital is required; though, of course, with persevering hard work and a little daring, such a trade might easily grow out of the beginnings described in the case of the small shop proprietor. The first-class firms all hold very extensive stocks, large portions of which must necessarily lie idle for years. They also keep deposits with a number of foreign postal departments to secure a good supply of new issues as they come out.

Advertising is another big item here, as the firm's name has to be kept constantly before the minds of the stamp-collecting public.

Stock, Premises, and Staff. In addition to the more comprehensive stock of stamps, he will require a more varied assortment of albums, handbooks, and other accessories. His shop fittings will be more elaborate, and the shop will be situated in a thoroughfare frequented by the well-to-do. A private office in which the manager can interview important customers, and transact "deals" which require diplomatic secrecy until effected, will be necessary. A shop manager at £3 to £5 a week, and a shop assistant at £1 to 30s., will probably be required for counter sales. A staff of girls, at 15s. to 25s. each per week, will be employed making up neat, attractive-looking packets for sale from 1s. to £15. Clerical assistance will also be required.

Stock Keeping. Most leading dealers have wholesale stocks, and can supply wholesale as well as retail. Heavy stock of common stamps may be warehoused, but stocks of used or unused good stamps, if laid away for a rise in value, will have to be deposited in a safe vault. The general stock is kept in big stock books, supplied with shelved strips in which the stamps are all classified. From these big stock books the shop counter and approval books (usually one and the same, counter books being sent out on approval when first made up) are compiled at intervals as required.

Approval Books. These books will contain stamps of individual countries, and each book will have to be made up by men who have knowledge of the particular country. Payment for such work, if done at home, varies from £1 to £3 per book for the smaller countries, and £5 to £10 for the more important ones. A book when made up, with notes pointing out the special features of the stamp, will be priced by the head of the firm, or another responsible member of the staff, and the book will be sent to the most important customer known to be interested in the stamps of the country. He will pick out the "plums," the book will then be sent to another, and so on. Or if there are no specialists in that particular country's stamps on the firm's lists, the book will be placed in the safe, and produced whenever required for counter sales.

Following Up Rarities. The proprietor of a high-class business must be keen in following up the scent when an important collection or a great rarity is for sale. If a firm sell a £1,000 stamp, even on commission terms at 10 per cent., it is a good deal, and brings credit and advertisement to the firm. A collector is greatly influenced in favour of a dealer if the latter secures for him a specimen for which he has hunted everywhere else in vain. The leading dealer must devote his best energies to tracing and securing the rarities. Such stamps need never be put into stock. As soon as they are found, there are purchasers eager for them to complete their collections. The special fancies of every customer of note will be familiar to the dealer, so that he knows where to place every uncommon variety as soon as it turns up. In fact, a card index should be kept of collectors' addresses and the countries in which they are interested, what their collections contain, and what they lack. Want lists will be solicited from all collectors, and must be executed as far as possible when they come in, and the remainder filed and indexed to supply at the first opportunity.

Trade Discounts. If one dealer send to another for a stamp which the first wants for a customer, he is generally allowed a discount of 10 per cent. This is also the discount allowed on a large sale on commission, while a similar transaction in a small way would be worth 25 per cent.

POST OFFICE SUB-AGENTS.

A distinction must be drawn between a district office, a branch office, and a sub-office. The first two are completely under Government control. The whole of the office is devoted to postal work, and the wages, hours of labour, and holidays of the employees come under the regulations of the Postmaster-General. For particulars of this branch of the Civil Service see "The Post Office Service" [page 2807].

A Sub-office. We are here, however, dealing with a different kind of postal work—that of a sub-office which is under a district office, and is undertaken by a shopkeeper as an addition to his ordinary trade. Such a combination offers distinct advantages to him. It introduces customers, who, when once on the premises, take the opportunity of making purchases. Then, the profits reaped from the postal department are by no means to be despised.

Naturally, certain businesses are tabooed by the authorities. In villages the office is frequently located in the shop of a general dealer or draper, but in towns or surburban districts those most favoured are chemists, stationers, confectioners and grocers, and sometimes, though rarely, bakers. A post-office, for obvious reasons, is seldom granted to a man holding a licence for the sale of wines and spirits. Occasionally the grant is withdrawn; it would be so were gambling or betting known to take place in the shop. Only two months' notice of withdrawal of the grant is given, and no compensation or pension is forthcoming.

The Grant from Government. The method of procedure followed by a shopkeeper wishing to add a post-office to his or her business is to send to the authorities a petition signed by the local residents. Such a petition would be available for signature in the shop, and would naturally indicate the need for, and the advantages of, such a grant. In a growing neighbourhood several such petitions may be received almost simultaneously. Inquiries are then made, and the shop most suitable, from the point of view of position and character of trade, is then chosen.

Commissions. At first sight the coveted distinction may appear a somewhat empty one, when one finds that a postmaster in a village may get the small salary of £10 or £12. A certain busy grocer in a surburban district is allowed the

somewhat nominal "responsibility" salary of £48, increased later to £50; but he gets a good commission on certain sales—in the case here referred to £200 a year—out of which, however, he has to pay his staff. The postmaster has no information as to the working out of commissions on his business. That is all calculated in the head office, to which accounts are sent every day to be worked out by the clerks employed there. The result may not be called in question by the postmaster.

The items on which commissions are reaped are telegrams, postal-orders, savings bank transactions, and money-orders. The commission is at the rate of one penny on every telegram forwarded or received. On postal-orders it is now paid once a year, at £1 per 1,000. On money orders it is one penny on each order, and the same holds good of savings bank transactions.

A sub-office may be knocked up to send a telegram after closing hours, on which there is an extra fee of 2s., or more, out of which a messenger has to be paid to fetch the clerk, the clerk paid for coming to telegraph, and probably porterage paid for delivery at the other end. Therefore, the margin of profit is in this case small, though to the public 2s. seems a high fee.

Express letter work is naturally undertaken only by an office open for telegraph work, and the Government reaps the benefit of the sale of extra stamps. The sale of stamps, by the way, which involves most work in a post-office, brings absolutely no profit, nor is there any commission on letters or parcels.

The postmaster, on undertaking postal work, signs a bond, under which he is responsible for a certain amount, all of which he runs the risk of losing; but the step is necessary as a guarantee of his financial soundness.

Assistants. In a sub-office one, two, or three assistants may be necessary, whose salaries, unlike those of fellow-workers in a Government office, vary very much, not merely according to the amount and value of their work, but according to the liberal-handedness or stinginess of the postmaster. Applicants are certainly more likely to apply for posts in a neighbouring office attached to a grocer's shop, where the three clerks have their meals, but sleep at their own homes, and receive respectively 18s., 16s., or 12s. a week. Three clerks to a sub-office is a generous allowance. The hours of work average nine a day, but are in some cases 12. Leave of absence is arranged by the chief clerk. The usual holidays are Sundays, Christmas Day, and Good Friday, in addition to a fortnight in the summer.

The clerks take it in turn to be away on Bank Holidays. They get no pension or wedding-present, as clerks in Government offices do.

Telegraph boys and postmen are all under Government control, except in a country office, which is hardly worth having.

How to Enter a Post-office. A girl desirous of becoming a clerk in a sub-office has no competitive examination—in fact, no examination whatever to encounter. She comes into the office as a learner without salary. If she proves capable, after a time she receives a small salary. Every branch of the work has to be mastered by her. Advertisements for such learners will frequently be found in, for instance, the "Christian World." The sub-agent is not allowed to take premiums with his employees. In a country office the junior clerk may be wanted to keep the books of the business or perform housework; not, however, in a London sub-office. She occasionally assists in a light business when the postal work is slack; but all such additional work is discountenanced by the officials, who sometimes institute inquiries respecting this matter.

It will be readily understood that it is an advantage to a postmaster to employ one or more members of his own family in the post-office, especially in country districts. The daughters often naturally slip into such vacant posts.

Fittings. The rear end of the shop is a favourite place for conducting post-office business. Here is a counter usually wired off above, with two or three drawers underneath, and space for stationery stores, two or three stools, pigeonholes at the side for papers, and scales for weighing parcels. The scales are supplied by Government, and are marked with the broad arrow. Fitted to the wall on the public side of the counter are compartments, with ink, pens, and blotting-pads for the use of the public. Letter boxes are also affixed outside. £20 covers the initial expenditure.

Telegraphy. This is an important part of post-office work, requiring considerable gumption, knowledge, nerve, and energy as well as physical strength when the work is continuous. A learner takes, on an average, two years to master the Morse code thoroughly. The code is put into her hands to be studied; then other clerks send messages to her, as opportunity offers. Occasionally one learner interchanges messages with another, a plan which has disadvantages. In many sub-offices, telephones are now found. This subject is dealt with in a separate article.

London sub-offices have sorting offices in a separate building, the sorters being Government employees.

Books of Reference. All necessary information concerning new rules, or alterations in old ones, is supplied to the sub-office for the information of the clerks. Guide-books for reference are forwarded in abundance once a quarter, as well as "rule-books" concerning telegrams, money-orders, and details of office work, so that all information is ready to hand. This is an important matter in a busy office, as anyone will agree who notices the stream of questions which the public put to the post-office clerks. Post-office servants are sworn to secrecy, and have to promise not to open letters, delay their delivery, divulge the contents of telegrams, or give information about another customer. A formal declaration has to be made at the police-station.

Continued

THE HOSIERY INDUSTRY

The Growth of Hosiery. Yarns and Fabrics. Hand Knitting. The Knitting Frame; Its Details and Methods of Working

Continued from page 4502

By W. S. MURPHY

WOOLLEN cloth caps were worn by the peasants of Northern Europe, and of England and Scotland, before the Norman Conquest, and knitted wool gradually and quietly superseded the woven cloth. The first historical record of which we can find trace is in the Act of Parliament, dated 1488, during the reign of Henry VII., in which the price of knitted caps is stated to be 2s. 8d., about 9s. of our money. During the following century knitting was frequently mentioned in legislation, and in the famous Statute of Labourers, passed in 1563, the hosiers are classed among the craftsmen whose contracts were to be regulated by that Act. The great Churchmen and Royal personages of Europe had set the fashion of covering the lower limbs with hose, at first of cloth, and later of knitted silk, and the Royalty and nobility of England followed suit. Howell, in his "History of the World," states that Henry VIII. ordinarily wore cloth hose, "except there came from Spain, by great chance, a pair of silk stockings."

From the high importance which the Court chroniclers seemed to give to the gift of a pair of silk stockings to Edward VI. by Sir Thomas Gresham, those commodities must have been rare and costly at that time. We may take that gift, however, as marking the end of the mediæval age of the industry. During the reign of Edward's sister Elizabeth the modern era began—the age of invention, of machinery, of vast industrial expansion.

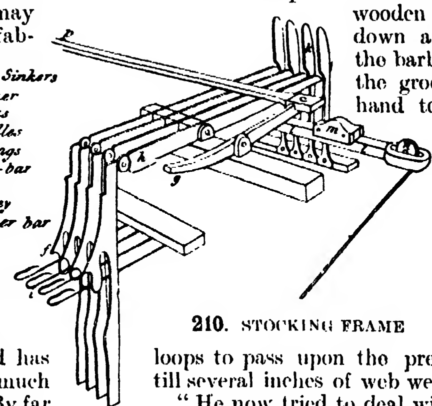
Hosiery Yarns. The hosiery industry uses many classes of woollen, worsted, merino, cotton, and silk yarns. During the past thirty years important changes have taken place in the yarn department. Before the period indicated, thick worsteds, five-ply and over, were the staple yarns of the popular stocking trade. Merinos were almost wholly mixed cotton and wool. The cottons most favoured were soft and thick. Silk, both thrown and spun, was in very small demand. Fancy hosiery had almost gone out of fashion. Between 1870 and 1900, however, a vast change occurred. Fine merinos of pure wool, formerly reckoned too costly for hosiery, came into use; cotton yarns of the finest counts and the highest quality became common; silk hosiery once more revived; fancy hosiery regained its hold on the popular market. All over, the demand for hosiery has increased enormously, and the desire for good quality has grown in even greater proportion. Silk stockings, socks, and other articles of underwear, are largely worn by members of the upper, middle, and professional classes, both male and female. In the fancy hosiery trade the change is equally well marked. No design is too fanciful to command a sale, though good taste, combined with bold originality, is surer of a permanent hold than mere eccentricity. The artistic pleasure in wearing dainty and pretty things for personal satisfaction, not for display, has spread into all ranks of society. Woollen hosiery has also come into larger demand because of the higher standards of life which obtain among the labouring classes. These are facts which should be observed by the worker in the hosiery industry. Supplying a personal need, he should pay very particular attention to the changes in personal need and taste prevailing among large classes of the community.

Fabrics. The range of articles made by the hosiery industry is very great. Between 5,000 and 6,000 articles are regularly manufactured and sold. Stockings, socks, shirts, vests, pantaloons, pyjamas, petticoats, caps, baby-hoods, jerseys, bonnets, gloves, mittens, slippers, and a vast number of other things of many varieties and classes employ the hosiery workers. On the one side, the hosier comes into close competition with the lace manufacturer, and on the other side he encounters the cloth weaver. In most cases it is difficult to say which is the invading party, the spheres of all three shading so gradually into one another.

Hand Knitting. Knitted fabrics are formed by a single thread, linked loop into loop, and may be made with two wooden pins or metal wires, named *needles*. Suppose we watch a knitter at work. First the basis must be formed. Holding the end of the worsted firmly against the needle in the left hand the knitter makes a loop on the right-hand needle like a running knot, and lifts it on to the left-hand needle. As many loops are made as there are stitches in the breadth of the fabric. Having got this foundation, the knitter inserts the right-hand needle into the end loop on the left-hand needle, passes the thread over the point of the inserted needle, with which she draws it through in the form of a loop, while slipping the first loop off the wire, thus making a loop or stitch. She works along the whole row in this way, and at the end we find that the right-hand needle has taken on all the thread, and now carries a row of stitches and a row of loops. The bared needle, which is always the working one, should be transferred to the right hand, and the loop-covered needle taken into the left hand. Again the knitter inserts the bare needle into the top loop on the left-hand needle, passes over the thread, draws it through as before, slipping the stitch thus formed on to the side of the row of stitches already made, forming another row of stitches

and another set of loops on the wires. When this row is completed, you can see clearly the beginnings of a knitted fabric, formed by the linked loops of a single thread.

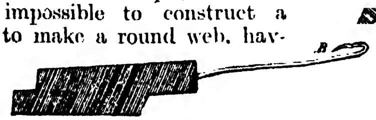
Styles and Qualities of Knitting. There are numerous styles of knitting; but two methods form the basis of most of our hosiery production. These are known among knitters as "plain" and "purl." Plain is the stitch we have just seen, and purl is the reversal of the same. One of the supreme merits of knitting is the facilities it affords for any shape or form being made without any seam. A seamless round web, shaped as a stocking or shirt, may be made with four wires. Knitted fabrics, being constituted of one thread continuously looped, and having neither warp nor weft, are soft, flexible, and elastic, lie close to that part of the body for which they have been made, and retain their shape after much wear.



210. STOCKING FRAME

Invention of Knitting Frames. William Lee, M.A., of Calverton, in the county of Nottingham, is entitled to rank among the very few original inventors the world has seen. Originality in invention is much rarer than most people suppose. By far the greater number of even the greatest inventors were merely improvers of mechanisms already existing. James Watt transformed the steam engine; but there were steam-engines working before he was born. With William Lee the case was quite different. No knitting machine had ever been constructed or even thought of, so far as we can gather, before he made the stocking frame [210]. He had to form the idea, and work it out in practical shape without one ray of guidance from past experience. Gravener Henson, in his "History of the Frame-Work Knitting and Lace Trades," thus describes Lee's method:

"The web of a stocking is knitted by hand, on three or four long pins, of a row of loops, and in a round shape; it seemed to Lee impossible to construct a machine to make a round web, having as many needles as loops in the circumference of the hose. Pondering on the difficulty, he one day saw his mistress knitting the heel, using two needles only; one held the loops, while the other was employed in making a new series. It struck him he could make the web flat, or in a straight line of loops, and when thus made, join the selvage by seaming them together and thus make it round. He was thus led to the idea of throwing a thread across a long elastic hook, the point of which would be pressed down into a hole in the stem of the wire, and thus loop at pleasure. He bored the holes, and tried to insert the point, but though he could make the loop on the wire, since called a needle, it would not slide easily over the inserted point. At length he thought of the groove instead of the hole. . . . In his first attempt at looping he inserted firmly into a piece of wood a dozen of these needles, eight to an inch, fixing this piece of wood upon a wooden framework, and endeavoured to make a succession of loops upon them by hand, which he finally accomplished, knitting on this row of hooks a pair of garters in this manner.


211. PRESSER BAR AND NEEDLE

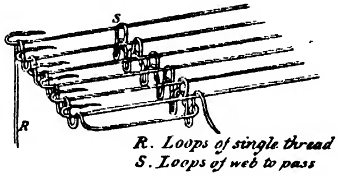
"The next point needed was to form and fix a wooden bar [211 A] to press down at one movement all the barbs of the hooks into the grooves, using the one hand to bring forward the loops, while he put down all the beards into the grooves with the other. So, by passing the row of loops over the beards and the heads of the needles, he formed row after row of loops to pass upon the previously-made rows, till several inches of web were produced [212].

"He now tried to deal with the single thread with which his web was to be made, so as to gain a sufficient length of yarn on each loop, and so to form a succession of loops across a series of needles [210*i*] placed in a straight line. . . . This, after many efforts, was effected in the most ingenious manner by the construction of what are called the jack and sinker. The jack [210*h*] is a lever working freely on a wire, upon which it is balanced. In Lee's frame these were of wood, one to each needle, and the whole row of jacks were kept in place by working in a comb. In the round head of the jack is a slit from which the sinker hangs and works perpendicularly. The sinker [210*f*] was made by Lee from a thin plate of tin, and is shaped by passing between the needles so as to carry down as much thread as will form a loop between each pair, then to carry them forwards under the needle beards and close to their heads; and after the presser had placed the points of the beards in their grooves the sinkers brought forward the web of loops already formed, and passed it over the last row formed, then took the work back to the stems of the needles ready for a new course. . . .

"The jacks, when the sinkers were attached, were lighter behind than in front, so he placed a row of light springs [210*k*] at their tails to hold them from falling forwards, except when wanted to form a fresh row of loops. Then they, following the thread thrown by the workmen each way, were forced down in rotation by an iron instrument of suitable shape, called a slur cock [210*m*], which, pulled by a string attached to treadles, runs backwards and forwards on a bar [210*l*], and by striking against the jack tails in succession, causes the hissing sound heard in framework knitting."

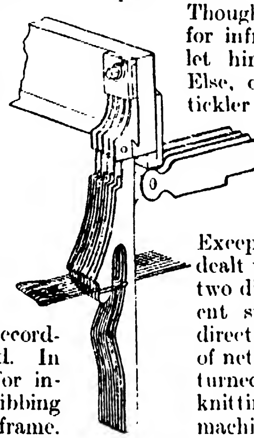
Fixed Sinkers. Aston, an apprentice taught by Lee, devised a frame which had one fixed sinker between every movable jack-sinker, and double the number of needles, thus doubling the gauge and capacity of the knitting frame [213].

Tuck Presser. Invented about 1740, the sliding tuck presser is a thin bar of iron attached to the frame presser, its lower edges grooved so as to lift some of the loops over the heads of the needles, while letting others remain, till the ordinary presser comes and passes the whole range of loops over the heads of all the needles.

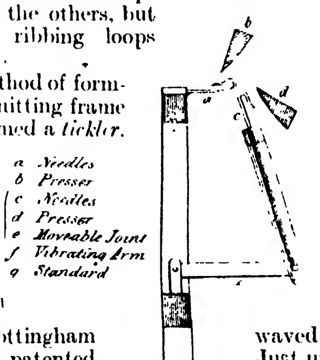


212. LOOPING ON NEEDLES

Ribbing Appliance. The tuck presser gave the knitter a certain power of changing the action of the needles, and this suggested further development. In 1758, Jedediah Strutt, of Derby, invented an appliance which solved the problem of ribbing, and opened up the way for a succession of inventions which revolutionised the hosiery trade. Strutt's apparatus [214] consists of an iron machine hung in jointed arms, *f*, in front of the ordinary frame. The needles, *a c*, in this apparatus are similar in form to those already in use, but the frame needles are set horizontally, while those of the ribbing appliance are placed almost perpendicularly, so as to work in between the former. The number of needles fixed in the added machine is regulated according to the number of loops to be reversed. In working one "purl" and one "plain," for instance, there are as many needles in the ribbing apparatus as there are on the knitting frame. When the knitting-frame needles have had their heads pressed, the needles of the ribbing machine are brought by its swinging motion in between them, penetrating those loops which are to form the ribbing, which, being passed under their beards, are reversed; then, being pressed again by the pressers, *b d*, the loops pass over the needle heads with the others, but with the visible part of the ribbing loops showing the opposite way.


213. FIXED SINKERS

Many Inventions. A method of forming fancy patterns on the plain knitting frame was by the use of a long wire named a *tickler*. With this the weaver shifted the loops according to the pattern. To make this automatic would effect a saving of labour. A poor stocking maker of Mansfield, named Butterworth, hit on a practical solution of the problem, and, by one means or another, John Morris, a Nottingham hosier, obtained possession, and patented the idea in 1764. Morris's specification runs: "For making by a machine to be fixed to a stocking frame, eyelet holes, or network, having an additional row of frame tickler needles." This machine is worthy of special attention, because it shows the first step towards the development of the lace loom. Felkin thus describes it: "The tuck presser and ribbing apparatus were combined. The tuck presser brought the loops to be shifted to the needle heads; and, in order to make the eyelet holes, these were removed by a short, flat-pointed tickler fastened to a bar. These ticklers covered the beards, pressed them into the grooves, and then took off the loops, and by a side movement placed each of them on the next needle on either side, leaving a series of fast holes below the next course of loops."



214. STRUTT'S MACHINE

Improved Tickler. A. Else, an ingenious inventor, devised an apparatus to regulate the tickler's action on a sliding bar, doubling the speed of the machine patented by Morris. Though Strutt might have sued Morris for infringement of his patent rights, he let him alone; but Morris pursued Else, on the ground that the improved tickler was an infringement of his tickler patent, won the case, and annexed the improvement.

Hand Knitting Frames. At this point we must leave the story of hosiery invention. Except in a few particulars, afterwards dealt with, the course of invention took two directions not cognate to the present stage of our inquiry. The one direction was towards the development of netting and lace frames; the other turned directly to transforming the knitting frame from a loom into a machine, ultimately to be driven by power motors. In our study of the hosiery factory, the latter part of the outline of the vast subject is glanced through. Meantime, our interest is in the hand frames. By adding on to Henson's description of Lee's frame the improvements enumerated, we can obtain a fair view of the general character of the various hand frames now in use; but we purpose making ourselves thoroughly sure of an understanding of the machine by viewing the principal details in order.

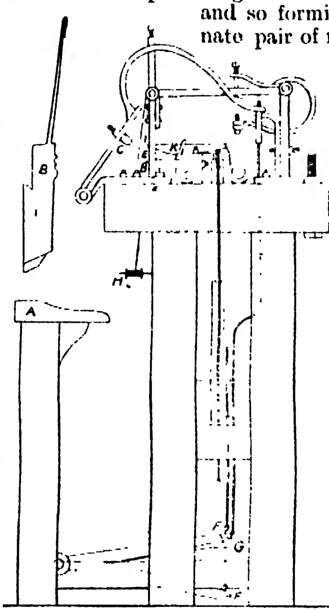
Needles. Two forms of needle may be taken as typical of the whole class—these are the bearded and the latch needles. Lee's needles were wires, peculiarly hooked. The hook was turned straight at the head, but the sharpened point was given a waved curve, which was called the beard. Just under the curved point the stem of the hook was grooved so as to admit the point of the needle when pressed down and to form a solid loop of steel. The form of this needle has been improved, the beard being straighter and easier to press down, thus obviating the risk of splitting the threads.

The latch needle, invented by M. Townshend in 1858, does away with the need of a presser bar, and is very useful in many kinds of modern frames. Instead of the curved beard, which is pressed into the groove, this needle has a hinged latch, or pin, with a fork at its point. The pin is hinged into the stem of the needle just below the point of the hook, with which it forms, when closed, a solid loop of steel. As the thread comes into the hook it throws back the latch. As it approaches to pass over the hook, the loop throws the latch into position and so passes over clear.

Sinkers. The function of the sinkers is to depress the threads for the formation of the loops. Originally the stocking frame had only one set of sinkers; but as we have it at present there are two sets—the jack sinkers and the frame sinkers. The former depend singly on levers, or jacks; the latter are fixed in a frame bar. Sinkers are thin metal plates, shaped like broad hooks with round points, which gently form the loops on the threads.

Jacks. The long levers which hold and move the sinkers are named jacks. They are actuated by springs driven by the slur cock.

Slur Cock. Along a bar under the jacks runs a small block named the *slur cock*, which, as it passes, lifts the jacks and so depresses the sinkers. The to-and-fro motion of the slur is imparted by a pulley at the side.



215. HAND KNITTING FRAME

Locker and Bar. When the sinkers have formed the loops, the locker [210*g*] is brought forward to fix them in position. The bar [210*p*] extends along the back of the frame, to be out of the way of the rest of the mechanism.

Pressers. There are different forms of presser. On the common hand frame the presser is a strong bar extending above the needles At the moment the loops are passing over the needles the bar is brought down to depress the beards and form the hook into a smooth loop The pressers on the rib hosiery appliance have a similar action.

Mountings. Ribbing apparatus, ticklers, brocade cylinders, and various other appliances for the making of fancy figures are fitted on to the knitting frame, and are technically described as *mountings*. These mountings are very numerous and varied in character.

Treadles. On the common hand frame there are three treadles. Two, one right and one left, are for bringing down the jacks; the centre treadle brings down the presser bar.

Working the Old Hand Frame. These parts are supported in a strong framing of wood, and at the centre is the weaver's seat [215*a*] Taking up his position, the weaver throws his thread, *h*, over the hooks by hand. Pressing the right foot on the treadle, *f*, he brings the slur along under the jacks, *k*, forcing down the sinkers, and so forming the loops between every alternate pair of needles. Then he brings the lead sinkers, *e*, down on the loops, to divide the loops over all the needles, locking up the jacks at the same time with the thumbs, and equalising all the loops by these combined movements. He brings the loops thus formed to the needle heads, *b*, throws up the frame with the help of the strong central spring, presses the centre treadle, *g*, to bring down the presser bar, *c*, carries the web over the needle heads, and lets the presser rise. Lowering the frame to the point at which the noses of the sinkers can catch in the work, he draws the web gently back. Finally, the knitter allows the frame to resume its balance, holding his thumbs firmly on the thumb-plate the while. When the frame has returned to its normal position he lets go, and begins another course.

Cottage and Factory. The use of the hand frame has greatly decayed, and the factory threatens to absorb the whole hosiery industry. On this fact Mr. Mundella, a well-known authority, passes the following judgment: "Notwithstanding the growth of the factory system, there is still a use for some thousands of the old hand frames; and the framework knitters, with their free choice of work hours, their independent position, their healthy life in rural villages far from the tyranny of the factory bell and the noise and unnatural conditions of modern manufacturing towns, preserve some traces of the days before the tall chimneys claimed human beings as mere details in a vast machine They may only be a survival, but perhaps they may maintain an old tradition until the dawn of a coming time when some motive power other than coal and steam shall restore to our toilers in many trades the conditions of life and work which the factory system has destroyed."

Continued

TRIANGLES AND PARALLELS

Perpendicular Lines. Construction of Parallels. Use of Set-squares. Third Case of Equality of Two Triangles. Right-angled Triangles

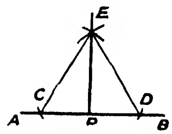
Group 21
MATHEMATICS
32

GEOMETRY
continued from page 4178

By HERBERT J. ALLPORT, M.A.

Proposition 15. Problem

To draw a straight line perpendicular to a given straight line at a given point in it.



First Method. Let AB be the given straight line, and P the given point in it.

Construction. From AB cut off any two equal parts PC and PD.

With centres C and D, and any radius greater than CP, draw two arcs cutting at E. Join PE. Then PE is ⊥ to AB.

Proof. Join CE, DE.

In the △s CPE, DPE,

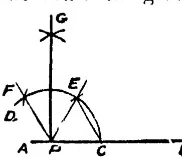
CP = DP, PE is common to both △s,

CE = DE, since they are radii of equal ⊙s.

∴ ∠CPE = ∠DPE (*Prop.* 7).

∴ each of these ∠s is a right ∠ (*Def.* 8).

Second Method. Let AB be the given straight line and P the given point.



Construction. With centre P and any radius, draw an arc CD. With centre C and the same radius cut this arc at E, and with centre E and the same radius cut the arc at F. From centres E and F, with any radius greater than half EF, draw two arcs cutting at G. Join PG. Then PG is ⊥ to AB.

Proof. Join PE, PF, CE.

The △ PCE is equilateral, since its sides are radii of equal ⊙s.

∴ △ PCE is equiangular (*Cor. Prop.* 5).

But the three ∠s of the △ make 180° (*Prop.* 14).

∴ ∠CPE = ⅓ of 180° = 60°.

Similarly, it can be shown that ∠EPF = 60°.

But ∠EPF is bisected by the straight line PG (*Prop.* 8).

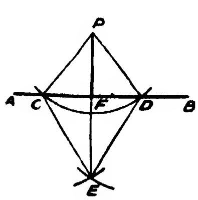
∴ ∠EPG = 30°.

∴ ∠BPG = 60° + 30° = 90°,

i.e., PG is ⊥ to AB.

Proposition 16. Problem

To draw a straight line perpendicular to a given straight line from a given point outside it.



First Method. Let AB be the given straight line, P the given point.

Construction. With centre P, and any radius great enough to reach a point on the other side of AB, draw an arc cutting AB at C and D. With centres C and D and any radius greater than half CD, draw two arcs cutting at E, on the other side of AB from P. Join PE, cutting AB at F. Then PF is ⊥ to AB.

Proof. The △s CPE, DPE can be proved equal in all respects (*Prop.* 7).

∴ ∠CPF = ∠DPF.

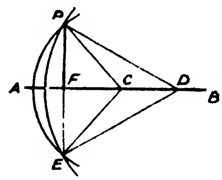
Hence, the △s CPF, DPF have two sides and the contained ∠ of the one equal to two sides and the contained ∠ of the other.

∴ they are equal in all respects (*Prop.* 4).

∴ ∠PFC = ∠PFD.

∴ PF is ⊥ to AB (*Def.* 8).

Second Method. Construction. In AB take any two points C and D. With centre C and radius CP, describe an arc. With centre D and radius DP, describe an arc cutting the first arc at E. Join PE, cutting AB at F. Then PF is ⊥ to AB



Proof. The △s PCD, ECD are equal in all respects (*Prop.* 7).

∴ ∠FDP = ∠FDE.

Hence, the △s FDP, FDE have two sides and the contained ∠ of the one equal to two sides and the contained ∠ of the other.

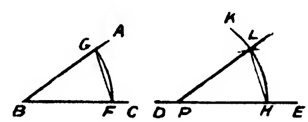
∴ ∠PFD = ∠EFD (*Prop.* 4).

∴ PF is ⊥ to AB (*Def.* 8).

Proposition 17. Problem

At a given point in a given straight line, to make an angle equal to a given angle.

Let P be the point in the straight line DE at which an angle is to be made equal to the given ∠ABC.



Construction. With centre B and any radius, describe an arc cutting AB and BC at G and F.

With centre P and the same radius, describe an arc HK, cutting DE at H.

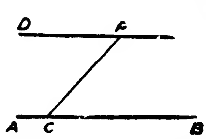
With centre H and radius FG, draw an arc cutting the arc HK at L. Join PL. Then ∠EPL is equal to the given ∠.

Proof. Join FG, HL. Then the △s BFG, PHL are equal in all respects (*Prop.* 7).

∴ ∠ABC = ∠LPE.

Proposition 18. Problem

Through a given point to draw a straight line parallel to a given straight line.



Let AB be the given straight line, P the given point.

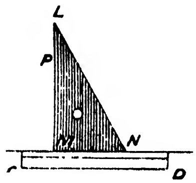
Construction. In AB take any point C. Join PC. At the point P in the straight line CP

make, by the construction of Prop. 17, the $\angle$DPC equal to the $\angle$PCB, and alternate to it. Then DP is $\parallel$ to AB.

Proof. Since the straight line CP meets the two straight lines DP, AB, and makes the alternate angles equal,

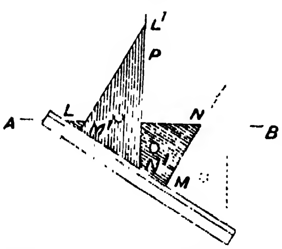
$\therefore$ DP is $\parallel$ AB (*Prop.* 11).

Note on Drawing Perpendiculars and Parallels. In practical work, perpendiculars and parallels are not drawn by using the constructions given in Propositions 15, 16 and 18. A set-square is used instead. This is simply a right-angled triangle, cut from thin wood, or other suitable material.



Suppose AB is a given straight line, and P a point through which we wish to draw a straight line $\perp$ to AB. If we place a straight ruler, CD, along the line AB, and put one of the perpendicular edges of the set-square against it, we can then slide the square along the ruler until the edge LM passes though the point P. By drawing the line LM we get the perpendicular we required.

There are two objections to this method. The one is that the corner M of the set-square gets rounded, through constant use. The other is that it is difficult to get the point of the pencil right up into the corner formed by the ruler and set-square at M. It is therefore much better to proceed as follows:



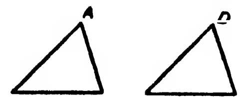
Place the *longest* edge of the square along the line AB, and put the ruler up to one of the other edges. Next, holding the ruler firmly, turn the square about the corner M, into the position shown by the dotted lines. We have thus turned the square through a right angle, and the edge LN is therefore at right angles to its former direction. Hence, if we now slide the square along the ruler until its long edge passes through the point P, *i.e.*, into the position L′M′N′, we can draw the perpendicular required.

Proposition 19. Theorem

If two triangles have two angles of the one equal to two angles of the other, and a side of the one equal to the corresponding side of the other, the triangles are equal in all respects.

If two $\angle$s of one Δ are equal to two $\angle$s of another Δ, it follows that the third $\angle$s of the two Δs must be equal. For the sum of the three $\angle$s of a triangle is equal to two right $\angle$s (*Prop.* 14).

Let, then, ABC, DEF be two Δs in which the $\angle$s A, B, C are respectively equal to the $\angle$s D, E, F, and the side BC = the side EF.



It is required to prove that Δ ABC = Δ DEF in all respects.

Proof. Place the ΔABC on the ΔDEF, so that B falls on E, and BC along EF. Then, since BC = EF,

$\therefore$ C must fall on F.

And since $\angle$B = $\angle$E

$\therefore$ BA must fall along ED.

And since $\angle$C = $\angle$F

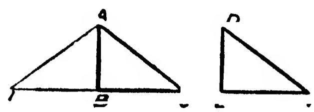
$\therefore$ CA must fall along FD.

$\therefore$ the point A, which is the intersection of the lines BA, CA, must fall on the intersection of the lines ED, FD, *i.e.*, on the point D.

$\therefore$ ΔABC coincides with the ΔDEF, and is equal to it in all respects.

Proposition 20. Theorem

If the hypotenuse and one side of a right-angled triangle are respectively equal to the hypotenuse and one side of another right-angled triangle, the triangles are equal in all respects.



Let ABC, DEF be two right-angled Δs, in which the $\angle$s ABC, DEF are right angles, the hypotenuse AC = the hypotenuse DF, and AB = DE.

It is required to prove that the Δs are equal in all respects.

Proof. Place the ΔDEF so that DE coincides with the equal side AB, and F falls on that side of AB away from C. Let F′ be the new position of F.

Then, since $\angle$s ABC and ABF′ are right $\angle$s.

$\therefore$ BC and BF′ are in a straight line (*Prop.* 2)

$\therefore$ AF′C is a Δ, in which AF′ = AC.

$\therefore$ $\angle$AF′B = $\angle$ACB (*Prop.* 5),

i.e., $\angle$DFE = $\angle$ACB.

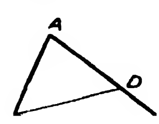
$\therefore$ in the Δs ABC, DEF,

$\angle$ABC = $\angle$DEF, $\angle$ACB = $\angle$DFE, AB = DE.

$\therefore$ the Δs are equal in all respects (*Prop.* 19).

Proposition 21. Theorem

If one side of a triangle is greater than another, the angle opposite to the greater side is greater than the angle opposite the less.



Let ABC be a Δ, in which AC is > AB.

It is required to prove that $\angle$ABC is > $\angle$ACB.

Proof. From AC cut off AD = AB. Join BD. Then, since AB = AD,

$\therefore$ $\angle$ABD = $\angle$ADB (*Prop.* 5).

But the exterior $\angle$ADB of the ΔBCD, is > the interior opposite $\angle$DCB (*Prop.* 10).

$\therefore$ $\angle$ABD is > $\angle$ACB.

Still more, therefore, is $\angle$ABC > $\angle$ACB.

Continued

ACIDS

Appliances and Processes in the Manufacture of Sulphuric, Nitric, and Hydrochloric Acids

Continued from page 4416

By CLAYTON BEADLE and HENRY P. STEVENS

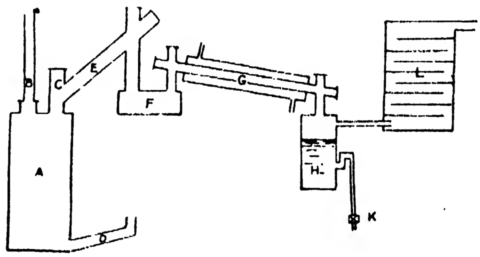
Sulphur and Brimstone. This substance is usually associated in our minds with fire and the nether regions. The popular superstition has some foundation in fact, as brimstone is found in the neighbourhood of volcanoes. Sulphur or brimstone is the main constituent of perhaps the most important of all chemical substances—namely, *sulphuric acid.* It occurs in nature as native sulphur in certain parts of the world, particularly Southern Italy, where it is sometimes extracted in a rather primitive manner. The sulphur ore, when poor in sulphur, is made into a heap, and the heat derived from burning a part of the sulphur melts the rest, which runs out and is collected. Such a process is, of course, very wasteful, but has the advantage of simplicity and cheapness. A better plan is to supply the heat by burning fuel and to allow the molten sulphur to collect.

Various Sulphur-recovery Processes. In other processes the sulphur is melted out by treating with a hot liquid, such as a saturated solution of calcium chloride, or by using superheated steam. All these processes are based upon the principle that the sulphur melts, leaving the earthy material behind. A recent adaptation of this process has been made use of to obtain sulphur from deposits in the State of Louisiana. In the neighbourhood of Lake Charles City there is a large deposit of sulphur under a layer of shifting sand, and 200 ft. to 250 ft. below the surface. The sand formed, until recently, an impassable barrier to the sulphur deposit, and all attempts to freeze the sand, a method which at other times has given satisfactory results, proved in this case unavailing. However, Frasch has recently patented and developed a method in which super-heated water, at a temperature of 166° C. is forced down into the sulphur deposit through a steel tube, and the molten sulphur forced up another tube placed inside the former (German Patents, 461429, 461430, 461431).

Sulphur can also be distilled, and it may pay to treat rich ores in this manner. The vapours are condensed and form *flowers of sulphur* if the cooling chamber be large and the temperature not allowed to rise too high, otherwise the sulphur melts. Molten sulphur run out and cast into blocks is known as *roll sulphur.* Distillation, however, is usually resorted to for refining sulphur.

Besides native sulphur, the element can be obtained from certain sulphides, particularly that of iron, known as *iron pyrites,* which occurs abundantly in various parts of Europe. This substance, if heated, parts with rather less than half of its sulphur, but the process is not used to a large extent for obtaining sulphur. Pyrites are more suitably employed for producing sulphur dioxide, as we shall presently see. Sulphur may also be obtained from coal gas by-products, such as the spent oxide from the gasworks. Here, again, it is better to prepare sulphur dioxide rather than sulphur from such sources. Sulphur can also be obtained by a number of processes from alkali waste, which consists largely of sulphide of calcium.

Carbon Disulphide. We have just mentioned this substance as a suitable solvent for sulphur. It is also largely used as a solvent for other substances. It is prepared by passing vapour of sulphur over red hot coal or charcoal. Vertical retorts are used constructed of cast iron, or earthenware, glazed inside [shown diagrammatically at A, in 1]. The lid



1. CARBON DISULPHIDE PLANT

of the retort is provided with two openings—one, B, for the introduction of fresh charcoal, the other, C, for leading off the vapours to the condenser, while the sulphur is introduced through an opening at D at the bottom of the retort. This opening is fitted with a tube sloping gently upwards, down which the sulphur runs, and is vaporised on flowing into the retort. The vapour passes up through the mass of charcoal, whereby the larger quantity is converted into carbon disulphide. The vapours leave the retort by a wide tube, E, sloping upwards, in which the sulphur condenses and flows back again into the retort, while the carbon disulphide, which is far more volatile, passes on into another vessel, F, in which any residue of sulphur is deposited. The vapours are condensed in a suitable condenser, G, and the liquid is collected in a receiver, H, and may be drawn off through the cock, K.

Any vapours of carbon disulphide which escape condensation are absorbed in a vessel, L, containing shallow trays filled with a vegetable oil. The crude carbon disulphide which still contains a small quantity of sulphur, is purified by distillation. When large quantities are taken,

such as five tons at a time, the distillate is collected in several portions ; that which comes over first contains most of the evil-smelling constituents. Sometimes the crude product is distilled over caustic soda, which holds back sulphuretted hydrogen and other impurities.

In place of caustic soda, certain metallic salts which react with sulphides, such as copper sulphate or chloride of lime, will serve the purpose. Thus, 100 parts of crude material may be treated with two or three parts of dry copper sulphate, and then redistilled over a fresh quantity of the same substance.

Carbon disulphide, or *bisulphide*, as it is sometimes called, is a colourless, very volatile, and heavy liquid, which has usually a very repugnant odour, due to the presence of small quantities of sulphur compounds. As already stated, it is an excellent solvent, and will dissolve elements such as phosphorus, iodine, bromine, chlorine, and sulphur, and a great variety of organic substances, such as rubber, camphor, fats, and grease of all kinds.

Care must be taken to avoid inhaling the vapours, as it is of a very poisonous nature, and would probably find a much wider use were it not for this circumstance. As it is, it is very largely employed in a number of industries for extracting fat and grease. It is also used in rubber factories [see INDIARUBBER] and for making viscose [see PAPERMAKING].

Sulphur Dioxide. The preparation of sulphur dioxide from native sulphur, pyrites, spent oxide, or other sources, is the first stage in the manufacture of sulphuric acid.

Spent oxide is a mixture of about equal parts of oxide of iron and of sulphur. In the neighbourhood of large towns, where much gas is burned, it is plentiful, and forms a good material for making sulphur dioxide. Brimstone is practically free from arsenic, and gives the purest product ; spent oxide is somewhat inferior, and pyrites, which always contains much arsenic, yields the lowest-grade acid. The brimstone, pyrites, or spent oxide, is heated in a small furnace, with the admission of sufficient air to combine with the sulphur to form sulphur dioxide. As a rule, rather more air than is necessary must be admitted into the furnace, and the process must be regulated so that as little sulphur as possible vaporises and sublimes unchanged. Owing to the excess of air present, some of the sulphur combines with more oxygen than is required to form the dioxide so that it becomes contaminated with sulphur trioxide (or sulphuric anhydride), SO_3.

Since the air contains only one-fifth part by volume of oxygen, the strongest gas produced cannot possibly contain more than 20 per cent. of sulphur dioxide. As a matter of fact, it does not usually contain more than 15 per cent. when burning sulphur, and only 8 per cent. when burning pyrites. In working with sulphur and spent oxide it is easy to avoid using a large excess of air, but with pyrites a larger excess is necessary in order to effect a thorough roasting of the material. In the manufacture of sulphuric acid, this is of little importance, as an excess of air always has to be admitted into the chambers, sufficient to oxidise the sulphurous to sulphuric acid. On the other hand, when preparing sulphites or a solution of sulphur dioxide in water, an excess of air should be avoided. Large quantities of acid calcium bisulphite are prepared for the manufacture of sulphite cellulose [see PAPERMAKING], and here also an oven which will produce sulphur dioxide gas with as small a percentage of free oxygen as possible will have the advantage. Liquid sulphur dioxide is often supplied in "syphons" [2].

2. SULPHUROUS ACID SYPHON

Brimstone and Pyrites Burners. The ovens for burning sulphur (brimstone burners) and spent oxide are comparatively simply constructed. They consist of a tray to contain material placed in a furnace, composed of an iron retort in the form of a long box provided at one end with well-fitting doors for charging, the other end leading to the flue. These doors have ventilating holes which can be opened or closed at will. In this way the supply of air can be satisfactorily regulated and the formation of sulphur trioxide avoided.

Pyrites burners are provided with a grate formed of bars on which the material is placed. Besides the lumps there is always some fine powder or "smalls," for which special furnaces have to be provided. In some works, when pyrites are burnt for preparing sulphite liquor the gases are led through a Kellner filtering tower, which contains lumps of limestone, so that the sulphuric acid is retained by the limestone as calcium sulphate. The tower is washed out from time to time with water.

Sulphuric acid has a greater tendency to be formed in the burners if moisture be present. If the temperature of the oven should get too high, some sulphur will be sublimed unchanged, and block the outlet pipes and flues, so that care must be taken to see that the furnace does not get too hot. This may be done partly by avoiding an excess of air, and partly by cooling the furnace. We can cool the furnace by placing a water-jacket round it, or else by playing a jet of water on to it. The colour of the burning sulphur is an indication whether the right amount of air is being admitted, as the sulphur should burn with a pale-blue flame tipped with white. If the furnace gets too hot, yellow-brown clouds of sulphur vapour make their appearance.

In some plants, that part of the sulphur which is not burnt straight away, but sublimes, has an opportunity of burning in an intermediate chamber before the gases are led away. In this manner the drawback common to most sulphur burners where the sulphur sublimes if the temperature gets too high may be avoided. In another plant a continuous supply of molten sulphur is burnt by subliming it and introducing air to burn the sulphur vapours. The sulphur dioxide then passes through a chamber loosely packed with bricks in which any sublimed sulphur deposits. The great disadvantage in working pyrites burners lies in the

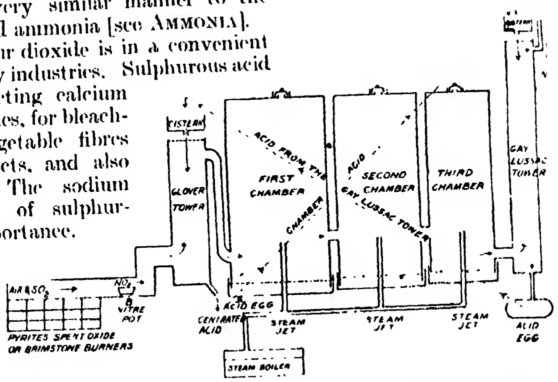
formation of much flue dust, which is carried along by the gases. Long settling chambers where the dust is deposited are necessary. In some plants the chambers have baffle plates, which effectively hold back the finely divided particles suspended in the current of gas.

Sulphurous Acid and Sulphites. The gas is led through a small quantity of water, which soon becomes saturated and no longer absorbs the sulphur dioxide but retains small quantities of sulphuric acid. The gas then passes into towers filled with coke, over which water is allowed to trickle, the excess of nitrogen escaping into the air.

For the preparation of liquid sulphur dioxide it is necessary to have the gas free from nitrogen, for which purpose a saturated solution of sulphurous acid is heated in a leaden retort. The sulphur dioxide which escapes is passed through oil of vitriol, which retains the moisture, and then on to a compressor, where it is condensed to a liquid in a very similar manner to the preparation of liquid ammonia [see AMMONIA].

This liquid sulphur dioxide is in a convenient form for use in many industries. Sulphurous acid is used for extracting calcium phosphate from bones, for bleaching all sorts of vegetable fibres and animal products, and also for disinfecting. The sodium and calcium salts of sulphurous acid are of importance.

Sodium bisulphite is prepared by saturating a solution of soda with the gas. The bisulphite ($NaHSO_3$) is converted into normal sulphite ($Na_2SO_3 7H_2O$) by adding to it a solution of sodium carbonate in the correct proportion. [For calcium and magnesium sulphites see PAPERMAKING.]



3. PLANT FOR MAKING SULPHURIC ACID BY CHAMBER PROCESS

Sulphuric Acid. It is considered by some that the manufacturing activity of any country may be very closely estimated by its consumption of sulphuric acid. It is perhaps the most important of chemical substances, and the basis of many important industries. There are two methods of manufacture termed respectively the *chamber* and *contact* processes, both of which are worked on a very large scale in this country. The contact process is comparatively new, but is likely to supersede the older chamber process.

We shall consider the chamber process first. We have already shown how large quantities of sulphur dioxide and sulphurous acid may be prepared by burning sulphur or spent oxide, or by roasting iron pyrites. The whole process of the conversion of this substance into sulphuric acid lies in the addition of one atom of oxygen to the molecule of sulphurous acid ($H_2SO_3 + O = H_2SO_4$). Sulphurous acid solution in contact with air is slowly converted into sulphuric acid, but the process is too slow and cumbersome for manufacturing purposes. It has long been known that the higher oxides of nitrogen give up oxygen to sulphur dioxide, converting it into sulphur trioxide, which on contact with water produces sulphuric acid. This is the chamber process in a nutshell.

The lower oxide so formed reforms the higher oxide by contact with air and is again reduced with formation of more sulphuric acid. The oxide of nitrogen acts merely as a carrier without itself undergoing any permanent change. Theoretically, then, a very small quantity of oxides of nitrogen is sufficient to convert an unlimited quantity of sulphurous into sulphuric acid provided sufficient air and water be present. In practice, however, there is always a loss of oxides of nitrogen, as will be seen shortly. The chemical changes may be represented thus:

SO_2	+	NO_2		H_2O		H_2SO_4		NO
Sulphur dioxide		Nitrogen peroxide		Water or steam		Sulphuric acid		Nitric oxide
	$2NO$	+	O_2		$2NO_2$			
	Nitric oxide		Oxygen from the air		Nitrogen peroxide			

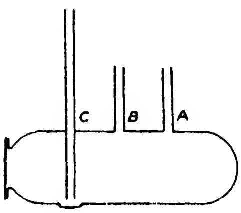
Fig. 3 illustrates the formation of sulphuric acid in the chamber process. Sulphur dioxide (SO_2), obtained by burning pyrites, spent oxide, or brimstone, reacts with higher oxides of nitrogen (NO_2), obtained from nitre, to yield sulphur trioxide (SO_3) and the lower oxide of nitrogen (NO). The sulphur trioxide (SO_3) combines with the water (H_2O) from the steam to form sulphuric acid (H_2SO_4), while the lower oxide of nitrogen (NO) combines with the oxygen (O) from the air to form the higher oxide of nitrogen (NO_2), ready to give up this oxygen again to a further quantity of sulphur dioxide with the formation of more sulphuric acid, and so on indefinitely.

Working Processes. Having now explained the principle of the "chamber" process, we will shortly describe the construction of the plant [3] and its mode of working.

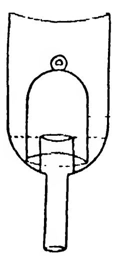
The flue gases from the sulphur or pyrites burners are brought into contact with oxides of nitrogen evolved from pots containing nitre and sulphuric acid placed in the flue, whence they pass together into a series of "lead chambers," supported on a woodwork frame and resembling boxes without bottoms. They stand in large leaden trays sealed by a water joint as shown in the figure. They have to possess a certain cubic capacity for every pound of sulphuric acid produced. Steam jets supply the water necessary to complete the reaction. The sulphuric acid condenses and collects at the bottom of the chamber from which it is drawn off.

The escaping gases consist of atmospheric nitrogen and unconsumed oxygen and steam. They hold mechanically some quantity of oxides

of nitrogen and sulphuric acid. If allowed to escape they would pollute the atmosphere and add to the cost of production through waste of the valuable oxides of nitrogen. To avoid this loss they are conducted to the bottom of the "Gay-Lussac" tower [see **3**]. This tower is usually cylindrical, and built of lead like the chambers. It is filled with coke and provided at the top with a cistern to hold "chamber acid." This acid collects in an oblong vessel under the chamber, termed an acid "egg" [**3** and **4**], whence by air pressure it is forced up to the cistern in the top of the tower. Thence it finds its way through a number of "lutes" [**5**] fixed in the lead roof of the tower, and, trickling down over the coke, absorbs and carries with it the greater portion of the nitric fumes contained in the ascending current of gases. A means must now be found for freeing the acid from the oxides of nitrogen and conveying the latter into the chambers for further action on the sulphur dioxide. This is effected by means of a "Glover" tower, which is built on a similar principle to the Gay-Lussac tower.



4. ACID EGG



5. ACID LUTE, OR DRIP

The sulphuric acid containing the oxides of nitrogen is forced up into the cistern at the top of the tower, and as it descends it meets the hot flue gases from the pyrites burners, with the result that the sulphuric acid gets heated, and most of the oxides of nitrogen and some of the water are driven off and carried along with the flue gases. It will be seen, then, that the sulphuric acid in the Glover tower not only gives up its oxides of nitrogen, but, at the same time, is concentrated, while the steam and oxides of nitrogen are carried together into the chambers.

Chambers. Most works possess at least two, but usually not more than four of these chambers. The chambers, of course, vary in size according to requirements and output. They are connected together by leaden flues, the last chamber being connected with the Gay-Lussac tower. As already explained, there must be plenty of room in the chambers for the sulphur dioxide, nitrogen oxides, and steam to react with one another before they reach the Gay-Lussac tower. Of course, the faster the gases are fed into the chambers the larger the chambers must be built.

Avoidable and Unavoidable Losses. In any manufacturing process, the actual chemical changes which take place are never exactly represented by the theoretical chemical equations; and in the manufacture of sulphuric acid these chemical reactions are never quite complete, so that a certain proportion of sulphur dioxide and nitric oxides which is not dissolved in the Gay-Lussac tower escapes and is lost.

It is a question for the manufacturer of sulphuric acid whether it will pay him best to increase his production by feeding in the gases faster, and losing a larger proportion, or going to the expense of building and up-keeping larger chambers. In France a method known as *forced working* is employed. The amount of nitric fumes carried away from the chambers is considerable, but the plant is provided with extra large Gay-Lussac towers to counteract this. As just stated, the lower oxide of nitrogen, nitric oxide (NO), is not dissolved in the Gay-Lussac tower, but only the higher oxides, so that to prevent loss of oxides of nitrogen we must have a plentiful supply of air in the last chamber. This will ensure the conversion of any of the lower into the higher oxides before reaching the Gay-Lussac tower. For this purpose sufficient air must be admitted with the other gases, and the excess of air necessary will vary with the circumstances—that is, as to whether the sulphur dioxide is got by burning sulphur, spent oxide, or pyrites, and in the last case, whether rich or poor ore. From the equations we have already given it will be seen that enormous quantities of sulphuric acid can be made with only the smallest quantity of oxides of nitrogen, but in practice the action is too slow unless larger quantities of nitre are used.

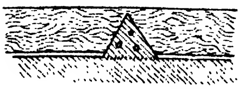
Working Conditions. It will be seen that the design and working of the sulphuric acid plant necessitates careful control and experience in using the right proportions of ingredients if the process is to work economically.

To give some idea, it may be stated that under the most favourable circumstances, working with plant which is in efficient repair and using a good class of pyrites, the supply of gas during the twenty-four hours must not exceed ten to eleven times the volume of the chambers when using three to four parts of nitre for every hundred parts of sulphur burnt. Under these circumstances, perhaps 1 to 2 per cent. of sulphur dioxide will escape conversion into sulphuric acid. To put it into other words, for every pound of sulphur burnt daily we must allow 16·2 cubic ft. of chamber space. If we economise the nitre, and use only 2·5 to 3 parts per 100 parts of sulphur, we must allow instead 19·8 cubic ft. In many works anything up to 25 cubic ft. may be found. By the method of "forced working" just spoken of, only some 12 cubic ft. are allowed.

Chamber Construction. The construction of chambers varies considerably. Of course, the larger the contained space per square foot of lead sheeting the better, so that the ideal chamber would be spherical.

In practice, chambers are usually made rectangular in form, using as few, and making them as large, as possible. A good method is to make the first chamber much the largest—say, two-thirds of the whole—as it is here that most of the chemical action takes place. The second chamber may have a capacity of two-ninths of the whole, and the third one-ninth. The weakest acid collects in the last chambers, so that they should be built each standing a little higher than the first, the weaker acid running down to the first chamber. The substance of the sheet lead, of which the

chambers are made, is in most cases somewhere about 6 lb. to the square foot. Sometimes the first chamber is built of heavier sheet, as the temperature is higher, and, in consequence, the wear of this chamber is greater. The lead is attached to a wooden scaffolding by tongues [6].



6. LEAD TONGUE FIXED TO A WOODEN BEAM

Chambers are connected by tunnels, which interfere least with the draught when they lead out of the bottom of one chamber into the top of the next; otherwise they are near the bottom, as illustrated.

Testing Progress of Operations. The whole process has to be carefully controlled. For this purpose instruments very like rain gauges are placed on the floors of the chambers. The rain of fine drops of acid is caught as it descends in the chambers. These "tell-tales" are provided at the bottom with a syphon from which the acid "drips" are collected. By taking the specific gravity of these "drips," and also of the bottom acid—namely, that which has collected on the bottom of the chambers—the progress of the reaction can be followed, and the supply of sulphur dioxide, nitric fumes, and steam regulated in accordance.

Chambers are also provided with glass peep-holes, so that the colour of the nitric fumes can be judged. Reference to the Pure Chemistry course will show that the lower oxide of nitrogen, nitric oxide (NO), is colourless, but when it combines with oxygen it forms the higher oxide, nitric peroxide (NO_2), which has a deep orange red shade. If the contents of the last chamber are pale yellow or colourless, it shows that there is either an insufficient supply of nitric fumes or else that there is not enough oxygen to convert them into the higher oxides. In the former case more nitre must be burnt, and in the latter more air let in. It is essential that the nitric fumes should be thoroughly oxidised before they reach the Gay-Lussac tower, as the higher oxides only are absorbed there.

Chamber Acid. The strength of the acid which collects on the bottom of the chambers will depend partly upon the amount of steam supplied. If the acid gets too strong—above 125 Tw., which equals s.g. 1·625—it begins to dissolve large quantities of the oxides of nitrogen, and not only would there be a loss of this valuable substance, but the acid would begin to act vigorously on the lead of the chambers. To avoid undue corrosion the acid is drawn off a little below this strength.

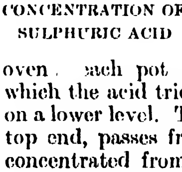
Acid cocks are very liable to get out of order, and it is usual to draw off the sulphuric acid (chamber acid) by means of a syphon. As the acid frequently has to be concentrated, some makers find that it pays them to allow the strength to rise to 140 Tw., the increased value of the acid compensating for the loss due to the corrosion of the chambers.

Gay-Lussac and Glover Towers. For the Gay-Lussac tower to do the work of recovering the oxides of nitrogen efficiently its capacity should be not less than 1 per cent., but preferably nearer 2 per cent., of the capacity of the chambers. The same applies to the Glover tower. The latter is usually built shorter and broader, and of heavier lead, often lined with firebrick, as the gases which enter it are very hot, and consequently have considerable action on the walls. It is filled with lumps of flint, as the coke used in the Gay-Lussac tower might catch fire if the supply of steam or acid were accidentally cut off. It is said that a considerable amount of sulphuric acid is formed in this tower—sometimes as much as 10 per cent. or 15 per cent. of the whole. In this way it acts as an extra chamber, besides concentrating the chamber acid, which trickles down it from the cistern on the top, and freeing it from the nitric fumes, which are carried on to the chambers. Gay-Lussac towers are sometimes built up of perforated acid-proof earthenware plates, which take the place of the coke. These plates are moulded so that a little pool of acid collects over each hole and drops through on to the plate below. This construction is more effective than towers filled with lumps of coke. These so-called *plate-columns* have also been used to replace chambers, and in some works alternate chambers and plate columns are employed. The latter are said to be ten to twenty times as effective as the former.

Concentration. Acid as concentrated in the Glover tower is impure. If pyrites acid, it contains arsenic and iron from the flue dust of the pyrites burners, also some oxides of nitrogen and lead sulphate from the walls of the tower and chambers. The arsenic can be got rid of by passing sulphuretted hydrogen through the acid, when it is precipitated as a sulphide, or by heating it with a little common salt, when the arsenic chloride, being volatile, is driven off.

To get rid of the oxides of nitrogen a little ammonium sulphate is added. The nitrates and nitrites of ammonia formed are decomposed when the acid is heated.

Having got rid of the nitric fumes the acid can be concentrated in lead pans to 145-150 Tw. When stronger, the acid goes for the pans, and for final concentration some more resistant material must be chosen. Glass and porcelain have the disadvantage that they are liable to crack and break suddenly, and cause much loss of acid, while platinum is very much acted upon, and the wear of the vessels is a very serious item in the cost of the process. In Webb's plant [7] porcelain pots provided with hoods are used, and the concentrating operation is continuous—that is to say, 20 pots or so are set in a line on a brick oven; each pot is provided with a lip, from which the acid trickles into the next pot, placed on a lower level. The acid flowing in weak at the top end, passes from pot to pot, and flows out concentrated from the bottom one. The acids, concentrated to 94 per cent. to 95 per cent., can be obtained absolutely free from water, either by adding to them some fuming sulphuric acid



7. CONTINUOUS CONCENTRATION OF SULPHURIC ACID

to convert the water into sulphuric acid, or by freezing the liquid, when the mono-hydrated acid (acid with one molecule of water) separates out.

Contact Process. We have explained the chamber process for making sulphuric acid; we now come to the second commercial process, which works without chambers. Although in some respects simpler, it is complicated by the fact that special precautions have to be taken to ensure the purity of the flue gases from the sulphur or pyrites burners. This section need not be studied except by the more advanced student and those who are anxious to acquaint themselves with the very latest methods for making sulphuric acid.

Reference to the course on Inorganic Chemistry will show that one of the methods of preparing sulphur trioxide is to pass a mixture of oxygen and sulphur dioxide gas over platinised asbestos, heated in a glass tube. $2SO_2 + O_2 + 2H_2O = 2H_2SO_4$. Sulphur trioxide, when dissolved in water, gives sulphuric acid, and the question naturally arose, Could this principle be applied to the manufacture of sulphuric acid? Early experiments in this direction seemed to show that the action is only partial when the sulphur dioxide and oxygen are much diluted with nitrogen, as would be the case in practice, where air would replace oxygen in the experiment mentioned above. We may, perhaps, mention here that the original discovery is due to Davy, 1817, and the first real attempts to apply it on a manufacturing scale, to Phillips, 1831 (British patent 6096). It was soon found that a number of conditions would have to be carefully complied with if the process was to be successful.

In the first place, the gases must be dry, and all dust and other impurities carefully excluded. The flue gases leaving the pyrites burners contain about 6 per cent. excess of oxygen over that necessary for the conversion of sulphur dioxide into sulphur trioxide. Knietsch has patented a successful process now working at Ludwigshafen on the Rhine. He found, in the course of his early experiments, that an excess of air had no influence on the oxidation process. His first experiment was made with artificial gases, and with such success that he soon began experimenting with the actual flue gases. These he led off from pyrites burners, through long tubes to deposit dust, and then dried them with sulphuric acid.

Contact Poisons. It was soon found, however, that the platinised asbestos, or *contact substance*, as it was called, began to lose its power, and no improvement was obtained by cooling the gases or further filtration and washing with sulphuric acid. This entailed a considerable amount of experimental work. Eventually, a number of laboratory experiments showed that certain elements are extremely injurious to the action of the contact substance—in particular, arsenic, mercury, and phosphorus, the last-named owing, perhaps, to the arsenic it contained. A number of other metals, such as antimony, bismuth, lead, iron, and zinc, were also found to clog up, and mechanically envelop the contact mass when introduced in large quantities. However, arsenic is the most troublesome "poison," not only because 1 to 2 per cent. on the weight of the platinum entirely destroys its activity, but arsenic is contained in all flue dust from pyrites burners. Moreover, the contact substance once "poisoned," it is difficult to effect a cure.

Having now discovered the cause of failure, it remained to find a remedy.

Prevention Better than Cure. Even the purified flue gases were found to contain a finely divided whitish mist of sulphuric acid, which could not be precipitated. The method eventually employed for purifying the gases consisted in gradually cooling them by leading them through a long dust flue and a set of lead pipes so that their temperature was reduced 100° C., and then through a series of mechanical washers, which were found more effective than washing towers, to retain the sulphuric acid. The gas is then dried over strong sulphuric acid and subjected to an optical and chemical test before going further. In the optical examination a layer of gas is viewed through a tube several feet in length to see if it is free from dust and mist.

In the chemical examination a current of the gas is passed for 24 hours or more through water, and the water tested for arsenic by the Marsh test [see ANALYTICAL CHEMISTRY]. Great care has to be taken to see that sulphuric acid does not condense on the iron flues on its way from the burners, as a certain amount of arsenuretted hydrogen is produced, owing to the liberation of hydrogen by the action of acid on the iron pipes. Arsenuretted hydrogen is a gaseous substance, and, once formed, would be carried on to the contact substance and rapidly poison it.

In the pyrites kilns there is always some very finely divided sulphur, which, under ordinary circumstances, is carried forward by the flue gases. This sulphur, as it would contain traces of arsenic, has to be got rid of by some means or other. It was found that directing a jet of steam into the kilns aids the combustion of the sulphur dust, and also brings about the condensation of any sulphuric acid present, so that the coolers do not become encrusted with solid impurities in combination with sulphuric acid.

By close attention to the foregoing details, it is possible to produce mixed gases on a commercial scale, and, in quality, free from traces of arsenic and other contact poisons.

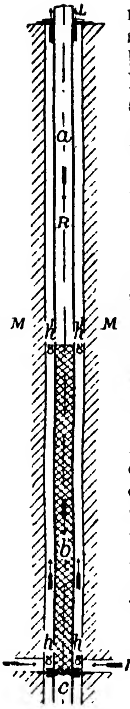
How the Heat Reaction is Controlled. When sulphur dioxide combines with oxygen to form sulphur trioxide, a very large amount of heat is evolved. This is in accordance with the equation ($SO_2 + O = SO_3 + 32{\cdot}2$ calories). A calorie is the unit for measuring quantities of heat. Put in other words, sulphur dioxide and oxygen combine to form sulphur trioxide, while at the same time 32·2 units of heat are produced, so that the sulphur trioxide formed is much hotter than the sulphur dioxide and oxygen before they entered into combination.

The reaction between the sulphur dioxide and oxygen in the presence of the contact substance takes place only when the gases are hot enough

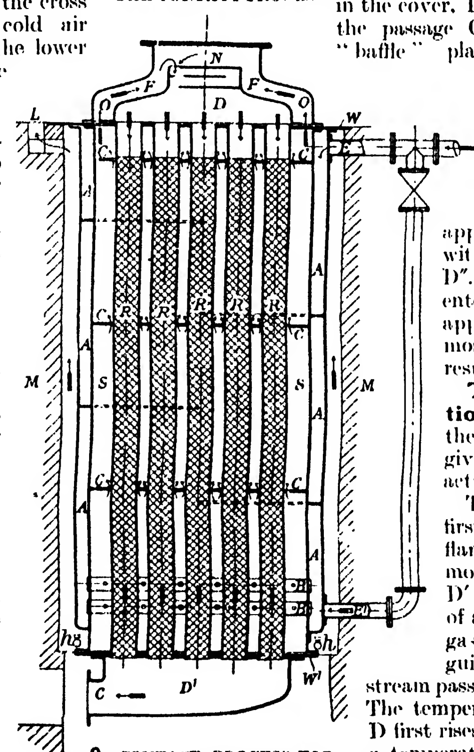
at the start—that is, when raised to a sufficiently high temperature. The heat produced by the chemical union of the already heated gases may be so great as to raise the mass to a bright red heat, and so prevent the permanent formation of sulphur trioxide, which tends to dissociate at very high temperatures. At the same time the iron parts of the apparatus are quickly destroyed by the action of the sulphur compound, and the efficiency of the contact mass is also reduced. This, of course, is due to the reverse action, the sulphur trioxide being broken up again into sulphur dioxide and oxygen, the reaction taking in both directions as shown by the arrows ($SO_2 + O \rightleftarrows SO_3$).

The Plant Described in Detail. It is, therefore, necessary to cool the contact substance, and in the early form of apparatus this was accomplished by means of a current of air. The plant for this purpose is shown in **8**, according to patent No. 15947, 1898. In a brickwork structure, or an iron tube, M, is fixed a tube R, leaving a space between the outside of the tube R and the inside of the brickwork of tube M. The two portions, *a* and *b*, of the tube R serve different purposes and may consequently differ from one another in length and diameter, and both parts can be replaced by a number of tubes. The one part, *b*, is occupied by the contact substance (indicated by the cross lines), and is cooled by cold air entering by the inlet *n*, at the lower end of the outer tube. In the other part, *a*, of the inner tube, the gases containing the sulphur dioxide, which enter at the upper end, are heated to the temperature necessary for the reaction.

When beginning the operation, the whole apparatus is first raised to the temperature necessary for the reaction by heating by means of gas flames, *h*. Then, if concentrated gases are used after the reaction has once begun, further heating is unnecessary, because the air cooling the contact mass absorbs heat and transfers sufficient heat to the other portion, *a*, of the tube containing the sulphur dioxide gases, to allow of the necessary reactions taking place in the contact mass *b*. The stream of air can be regulated by means of adjustable updraught openings, L, in such a way that the contact mass in the part *b* is constantly maintained at the temperature most favourable for the



8. SULPHURIC ACID BY THE CONTACT PROCESS



9. CONTACT PROCESS FOR SULPHURIC ACID MANUFACTURE

reaction. When the gases contain but little sulphur dioxide, the air, which is somewhat heated by its cooling action, is further heated by means of the gas flames, *h'h'*, so that the gases flowing in through the part *a* of the tube get more strongly heated. The gases, which now contain sulphur trioxide issuing from the contact mass in the part *b*, leave the apparatus by a pipe, *c*.

An Improved Method. Instead of using air for cooling the contact mass, it is much more economical to use the flue gases themselves. They thereby become heated up to a temperature sufficiently high for the reaction to begin. This apparatus is shown in **9**. It will be noticed at once that we have here a battery of five tubes instead of one, and that the whole of the tubes are filled with the contact mass. In order that the cooling gases may pass as closely as possible in contact with the walls of the tubes which contain the contact mass, there are inserted at intervals a number of partitions, C, C, extending across the chamber S, sufficient space being left for the gases to pass through close to the walls of the inner tubes, R, R, as indicated by the small arrows.

The gases should be thoroughly mixed before they pass into the contact mass, in order to equalise their temperature. This is done by means of mixing apparatus, N, fitted in the cover, D, the gases passing up the passage O F and between the "baffle" plates as shown. The strength of the current and the temperature of the cooling gases is regulated by noting the readings of thermometers fixed in various parts of the apparatus, and especially within the covers D and D″. Analyses of the gases entering and leaving the apparatus show when the most favourable practical result is being obtained.

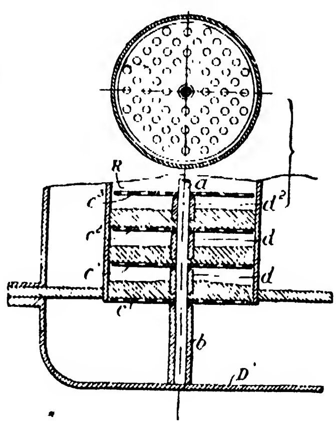
The Plant in Operation. In order to explain the mode of action we may give an instance taken from actual working.

The apparatus is heated first (say, by means of gas flames at *h'*), until a thermometer in the upper cover D′ indicates a temperature of about 300° C. Then the gas flames are extinguished, and the whole gas stream passes into the apparatus A. The temperature within the cover D first rises. When it has reached a temperature favourable for the reaction, a valve in the upper part

of the apparatus is opened, so that a part of the gases may enter directly, as shown by the arrows. The gases entering and leaving the apparatus are analysed to determine their contents of sulphur dioxide, and in this way we can see how the plant is working.

To Regulate the Temperature. About two-thirds of the entire gas current passes in at the entrance A to the chamber S surrounding the inner tubes R, and one-third directly into the top cover D. The temperature, which becomes uniform owing to the action of the mixing chamber N, in the cover is about 380° C., while the thermometer in the lower cover D′ indicates about 234° C. In this actual case, taken from experimental practice on the factory scale, a conversion of from 96 per cent. to 98 per cent. of that theoretically possible has been obtained while making from 40 to 50 kilogrammes of SO_3 per tube in 24 hours. The conversion can be increased to 99 per cent. if the gas be permitted to remain longer in the presence of the contact substance.

Filling the Contact Substance into the Tubes. The method of packing the tubes with platinised asbestos so that the gases shall come thoroughly into contact with the mass without having their flow too much impeded is seen in the next diagram [10]. A central iron rod, *a*, passes up the axis of the contact tube R; surrounding the bottom end is the short tube *b*, on which rests the perforated plate *c*. On this sieve plate is heaped the platinised asbestos, and then another short piece of tube, *d*, is fitted on to the rod *a*. This is followed by a second sieve tube, *c′*, carrying its layer of platinised asbestos; and then another short piece of tube, *d′*, followed by a third sieve plate, c^2, and so on.



10. SULPHURIC ACID BY CONTACT PROCESS

Instead of asbestos as a carrier for the platinum, a mass can be used prepared, for example, by heating barium chloride with ammonium sulphate. These substances interact and form barium sulphate and ammonium chloride, and, on heating, the ammonium chloride is driven off, leaving a very porous mass of barium sulphate. Further, an economy in the platinum can be effected by conducting the operation in two stages—thus, whereas 100 parts of platinum would in one operation yield 97 per cent. of the theoretical quantity of sulphuric anhydride, 15 parts of platinum would yield 80 per cent. If, now, this 80 per cent. be removed by absorption, the remaining 20 per cent. could be subjected to the same treatment, yielding eventually $80 + \frac{(20 \times 80)}{100} = 96$ per cent. yield of theoretical.

Spent contact substance may be regenerated by passing the vapours of hydrochloric acid mixed with some inert gas through them until all impurities are removed.

Sulphuric Acid from Sulphur Trioxide. The absorption of the sulphur trioxide or sulphuric anhydride with the formation of sulphuric acid is not so simple a process as it would seem. It is extremely difficult to dissolve sulphur trioxide completely in water or dilute acid. As one kilogramme of sulphur trioxide liberates 500 calories when dissolved in water, 300 calories when dissolved in 66° Bé sulphuric acid, it would seem that the best plan would be to have a continuous arrangement with a number of absorbing vessels, and to pass the gases through them in one direction and the current of water in the other, so that the strongest gas passes into the strongest acid, while the gas from which practically all the acid has been removed passes through pure water. Such an arrangement, on the same principle as Webb's sulphuric acid concentrating apparatus already described, does not work in practice, as there is much loss of acid owing to a whitish mist carried away in the current of gases. It is found, however, that a very strong acid, 97 to 98 per cent. (H_2SO_4), absorbs sulphuric anhydride immediately and completely, so that the absorption can be carried on in a single absorbing apparatus which is fed continuously with water or dilute sulphuric acid to maintain the strength at 97 to 98 per cent. (H_2SO_4).

Sulphuric Acid in the Atmosphere. We should not omit to mention that large quantities of sulphuric acid are produced quite unintentionally, the whole of which finds its way into the atmosphere. All coal contains larger or smaller percentages of sulphur due to the pyrites in it, and when burnt, whether on the domestic hearth or under a steam boiler, or in other manufacturing operations, the sulphur is oxidised to sulphurous, and eventually sulphuric acid. All the acid derived from house coal escapes up our chimneys into the air.

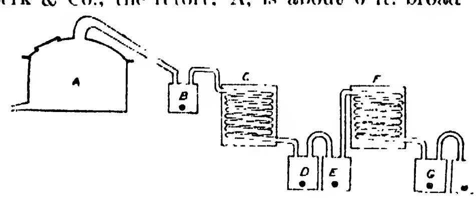
Combustion of a ton of coal produces about 68 lb. of strong sulphuric acid, and taking, say, the amount of coal raised annually in the United Kingdom, as 250,000,000 tons, of which we burn three-quarters ourselves, the atmosphere of Great Britain is contaminated with 5,700,000 tons of strong sulphuric acid per annum. A cubic yard of strong oil of vitriol weighs approximately 1·4 tons, so that the foregoing amount of sulphuric acid would occupy 4,000,000 cubic yards, sufficient to fill a canal eight yards broad, two yards deep and 115 miles long. This appalling quantity of sulphuric acid produced unintentionally by the coal we burn is more than twice as much as we manufacture for industrial purposes. Fifteen per cent. of the coal raised in Great Britain is burnt in our houses, so that a very large proportion of the enormous quantity of sulphuric acid

mentioned is produced by coal burnt for domestic purposes. All this acid poured into the atmosphere cannot but affect the buildings of large towns. It is carried down by the rain and dissolves away the surface of stone work, corrodes iron, and brings about decay generally. The whole subject was very fully gone into by Dr. Angus Smith many years ago, but very little has been done since then to mitigate the evil.

Fuming Sulphuric Acid. This acid consists of ordinary sulphuric acid with sulphur trioxide dissolved in it. It was originally made at Nordhausen, in Germany, by distilling green copperas (crystallised sulphate of iron) which had been exposed to the air. The acid collects in the receiver, while oxide of iron, or *colcothar* [see PAINTS], remains in the retort. Nowadays it is made by the contact process already described; obviously this should prove the most rational method of manufacture on a large scale. It is used in the colour industry.

Nitric Acid. We have already explained how nitric acid is prepared for the manufacture of sulphuric acid. Some manufacturers use ready-made nitric acid. It is prepared by distilling Chili saltpetre [see MANURES] with strong sulphuric acid from iron retorts. It is a very curious thing that nitric acid, when weak or moderately dilute, rapidly dissolves iron, but has little or no action on the metal when it is strong. The iron retorts are sometimes arranged so that the whole of them, including the upper part, is kept heated, in order that no acid condenses on the metal cover.

In the Valentia plant [11], as adopted by Berk & Co., the retort, A, is about 6 ft. broad



11. VALENTIA NITRIC ACID PLANT

and 4 ft. deep. The acid is distilled off under diminished pressure (say two-thirds of an atmosphere). The acid fumes are led into suitable condensing arrangements made of porcelain or glazed earthenware, and consisting of a series of Woulff bottles, that is to say, earthenware bottles, with two tubulars or flanged holes in the top. Each bottle is connected up with the next by means of an earthenware tube in the shape of an inverted U luted into the holes. From the retort the fumes pass into a Woulff's bottle, B, to condense any sulphuric acid carried over. The temperature here is too high to condense any nitric acid. Next comes a "worm," C, in which a good deal of acid condenses. The "worm" is an earthenware tube, corkscrew shaped and surrounded by cold water. Much of the nitric acid condenses in the worm and collects in two Woulff bottles, D and E. What escapes condensation passes through a second worm, F, and a long series of Woulff bottles, G, the last of which contains water to hold back any remaining traces of acid.

The quantity of sulphuric acid taken is some 30 per cent. in excess of that theoretically required in accordance with the equation, $2NaNO_3 + H_2SO_4 = Na_2SO_4 + 2HNO_3$ in order that the resulting nitre cake (sulphate of sodium) may remain sufficient fluid to be run out of the retort when the operation is over. It is utilised for making "salt cake" [see below]. The stronger the acid used for decomposing the nitrate, the stronger the nitric acid produced.

Pure nitric acid decomposes rapidly when heated, so that the crude product is always contaminated with red fumes. These consist of oxides of nitrogen such as are used in the chamber process. These red fumes condense with the nitric acid in the first bottles, and are easily driven out of the acid by a current of air. From what has been said it will be understood that the strongest nitric acid cannot be distilled unchanged. Strong nitric acid has a specific gravity of 1·42 and contains about 70 per cent. of pure acid. The very strongest and purest acid has a specific gravity of 1·5, that is to say, it is half as heavy again as water, and contains over 90 per cent. of pure acid. The strongest acid is used for making guncotton, smokeless powder, and other explosives.

Hydrochloric Acid and Salt Cake. Hydrochloric or muriatic acid is a combination of hydrogen with chlorine, and is used in considerable quantities in the preparation of chlorine, bleaching powder, and for pickling iron in the manufacture of galvanised sheets. Although in itself of considerable importance, it is formed as a by-product in the manufacture of alkali. The raw material consists of common salt, which is a compound of the metal sodium and chlorine. When decomposed with sulphuric acid the chlorine is liberated as hydrochloric acid gas and the sodium is left combined with the sulphuric acid as sodium sulphate. The operation is carried out in a special salt cake furnace, consisting of a pan to contain the salt covered with a brick hood or dome, with a tube leading out of it for carrying away the hydrochloric acid gases.

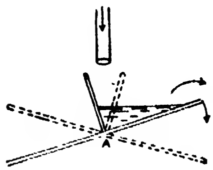
In this pan the operation carried out is represented in the main by the following chemical equation:

$NaCl$	$+ H_2SO_4 =$	$NaHSO_4$	$+$ HCl
Common salt	Sulphuric acid	Acid sodium sulphate	Hydrochloric acid

Sulphuric acid, sp. gr., about 1·7, such as comes from the Glover tower, is run into the pan, and the decomposition promoted by a fire underneath.

Absorption of the Gas. The reaction takes place with considerable violence, and torrents of gas are given off. These gases are led into towers filled with coke, similar in construction to the towers used in the chamber process for the manufacture of sulphuric acid, except that in this case water, and not sulphuric acid, trickles down from a cistern above. The water from the cistern flows into a trough which, as soon as full, tips over and discharges water automatically into the tower, and then re-fills

automatically and discharges again [12]. It is found in practice that an intermittent discharge is better than a continuous one. Two or three of these towers stand together, and when gas is not absorbed in one tower, it passes on, and is absorbed in the next. The Alkali Act sets a limit of ·2 grain per cubic foot for the amount of acid which may be allowed to escape into the air.



12.
WATER DISTRIBUTOR AT TOP OF HYDROCHLORIC ACID ABSORBING TOWER

Although hydrochloric acid is very soluble in water—the latter dissolves some 500 times its own volume of the gas—its absorption in the towers is not such an easy process as would at first appear. The gas is not given off evenly and uniformly during the reaction, but the greater part of it comes off with a rush at the beginning. At this time the absorbing power of the towers is taxed to the utmost. Then the gases are hot and require cooling, and they are also diluted with large volumes of inert gases, such as air—all which circumstances render it more difficult to ensure complete absorption in the towers. At the bottom the concentrated muriatic acid is drawn off.

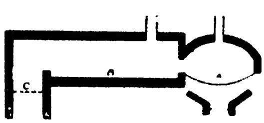
Open and Close Roasters. When the reaction in the iron pan, A, is complete, which will be in the course of an hour or so, the solid mass is raked forward on to a brick floor in another part of the furnace, B, where the heat is greater; here the reaction is completed, the mass being stirred up from time to time by a workman with a long iron crowbar, to prevent it from caking or crushing on the hearth.

The chemical reaction may be represented thus:

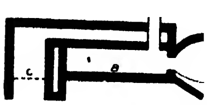
$NaHSO_4$	+	$NaCl$	=	Na_2SO_4	+	HCl.
Acid Sodium sulphate		Common salt		Neutral sodium sulphate		Hydrochloric acid.

But in practice the two reactions take place simultaneously, and cannot be sharply separated from one another. A small excess of sulphuric acid is often taken, over and above that actually required to produce the decomposition.

This part of the furnace is differently constructed, according to the purity of the product required [13 and 14]. If the salt cake be wanted for making alkali, the ordinary reverberatory furnace, or *open roaster*, is employed [13], where the flames and hot gases from the fire on the grate, C, play over the surface of the material on the hearth, B. If a purer and whiter product is wanted, such as is used by glassmakers and wood pulp boilers, a muffle furnace, or *close roaster*, is used [14], one in which the flames and hot gases do not come directly into contact with the material, but play round the firebrick box, B, in which the salt is contained. It is usual, in this case, to use a slight excess of sulphuric acid; the gases given off are not so pure as in the first part of the process. They are carried away and the acid absorbed in separate towers.



13. OPEN ROASTER



14. CLOSE ROASTER

One hundred parts of salt yield something like 116 to 120 parts of salt cake.

Mechanical Furnaces. Many inventors have devoted themselves to the construction of mechanical furnaces in the place of the roasters just described, to economise labour and fuel, and to avoid the risk of breaking the pans. The most successful of these is Mactear's, which consists of a revolving circular bed or pan into the middle of which the salt and acid are continuously fed. Over the bed is a fixed arch, the fire passing between them. The pasty mass gradually spreads towards the outer edge of the pan and stirrers carry it to the circumference, where it falls off the edge, collecting in a trough underneath, whence it is carried away. The salt-cake round the edge of the pan forms a lute and prevents the escape of hydrochloric acid under the pan, flues above being provided to carry it off. As the process is perfectly regular, the hydrochloric acid is given off in a continuous stream.

Salt Cake Without Sulphuric Acid. By the Hargreaves and Robinson process, salt is decomposed by a mixture of gases from the pyrites kilns—chiefly sulphur dioxide and air—without the direct intervention of sulphuric acid. The gases, mixed with steam, are led into cast-iron cylinders containing salt, when the following reaction ensues:

$2NaCl$	+	SO_2	+	O	+	H_2O
Common salt		Sulphur dioxide		Oxygen		Steam
	=	Na_2SO_4	+	$2HCl$		
		Sodium sulphate		Hydrochloric acid.		

In order that the reaction may be complete, a series of iron cylinders is provided, and the fresh gases are led first into the cylinders in which the salt has already been exposed for some time to treatment, finally reaching those freshly filled with salt, when the gases are nearly exhausted. Special precautions are necessary to allow of free passage of the gases; the salt is moistened with steam, pressed into cakes, and dried. In this state it is fed into the cylinders, the whole operation being conducted mechanically.

Properties of the Acid. The commercial hydrochloric acid is a fuming liquid, generally coloured yellow by the iron it contains. This iron is derived from the pans. Its purity will generally depend upon the purity of the sulphuric acid used to discompose the salt. If pyrities acid has been employed, the hydrochloric acid will contain arsenic. The common muriatic acid contains from 30 to 32 per cent. of hydrochloric acid gas.

Continued

THE MAKING OF WROT IRON

Finery Methods. Puddling. Modified Processes. Rolling Mills. Rolling Special Sections

By A. H. HIORNS

THE production of malleable iron from pig iron is divisible into two classes—the ancient or finery methods and the reverberatory or puddling methods, although the reactions are similar in both cases.

Finery Method. The graphite first passes into combined carbon and is then converted into carbonic oxide by the oxygen of the blast directly or indirectly by the action of oxide of iron dissolved in the slag. At the time of fusion the foreign elements begin to be rapidly oxidised. The silica unites with the oxide of manganese, together with some oxide of iron, and forms the slag. The ferrous oxide (FeO) of the slag acts as a vehicle for oxygen, uniting with the oxygen of the air and is converted into the magnetic oxide (Fe_3O_4). This coming into contact with impure iron oxidises the iron itself, being converted into FeO. After a time the slag becomes neutral, and is in part removed; then fresh basic and hammer slag are added. To complete the operation the iron in masses is lifted up to the twyer level in order to oxidise the carbon thoroughly. The white-hot mass of iron, which is of a spongy consistency, is then taken to a heavy hammer and compressed to a slab, termed a *bloom*. The subsequent treatment of the bloom varies in different countries. In Italy the partially-refined mass is taken out and cooled with water, then broken up and reheated sufficiently to allow the iron and the slag to cake together, when it is again removed. In the third stage the above mass of iron is reheated with a rich slag until it is practically refined.

Charcoal Iron. In South Wales a superior quality of tin-plate iron is made from the best pig iron in a charcoal finery. The pig iron is first partially refined in a special hearth, termed a *refinery*, and then treated in charges of 3 cwt. in the finery. The bloom of refined iron is then shingled and drawn out into a bar under a lever hammer. This bar is nicked, broken and made into bundles, then reheated and welded under a hammer and rolled into sheets. Before finishing, the sheets are annealed, pickled to remove scale, and rolled cold into sheets.

Materials for Wrot Iron. In the above finery methods white cast iron is more suitable for conversion into wrot iron than grey iron, since it does not pass directly into the liquid state, but assumes, when near its melting point, an intermediate pasty mass, which is favourable for the more effective oxidising action of the air and slags. Grey iron, on the other hand, requires a higher temperature for fusion and becomes very liquid, and in a deep hearth sinks below the level of the blast, becomes covered with slag, and is completely protected from the action of the air; the refining is delayed with the consequent expenditure of extra fuel and labour. For this reason grey iron was first converted into white iron in the refinery. In former times hearth refineries were called *bloomeries*. The reheating or welding fires were termed *chafferies*.

The old finery is a rectangular hearth, formed of cast-iron plates lined with charcoal, the bottom being exposed to the air. Three sides are vertical, while the remaining side slopes outwards. The blast is supplied by a single twyer. The fuel is charcoal. In the Lancashire hearth the blast is heated to about 100° C., and used at a pressure of 1 lb. to 1¼ lb.

Reverberatory or Puddling Process. The method of dry puddling in a reverberatory furnace was developed by Cort in 1784. The furnace bottom was dished out and lined with sand, which became glazed over with slag during the working. In later years the bottom was covered over with oxide of iron, formed by oxidising scrap iron in a strongly oxidising atmosphere. Each operation was composed of three periods—fusion, rabbling, and forming the blooms—white or refined iron being used. About 4 cwt. of refined iron were charged into a hot furnace, and partially melted in half an hour, forming a pasty mass, which was then stirred with iron tools to bring all parts under the influence of oxygen. As the impurities were removed and passed into the slag the iron became less fusible, requiring the temperature to be raised. The particles of refined iron were then collected into balls by the puddler, which were taken to the hammer and subsequently rolled. The reactions are similar to those of the finery, and the same kind of iron is used.

In 1830, Hall found that by using old furnace bottoms, which contained much oxide of iron, as a material for lining his puddling furnaces, the process was shortened and the preliminary fining in a refinery could be dispensed with. This caused the old brick furnace to be discarded and to be replaced by a frame of air-cooled iron plates. This was lined with calcined tap cinder (bulldog), which is still partially used. This method is characterised by the complete fluidity of the pig iron, and grey iron may be used.

The Puddler at Work. When the furnace is charged, the door is kept closed and the fires made up. When the iron is softened, the puddler, by means of an iron bar termed a *rabble*, moves the unmelted portions into the centre of the furnace and increases the temperature of the fire. When the whole is melted, it is rendered uniform by stirring and the damper lowered until the surface is covered with slag. In order to cause the slag to react on the molten metal, the whole is well stirred. The slag is also made more

basic by the addition of hammer slag and mill cinder. The oxide and silicate of iron react on the combined carbon, forming carbonic oxide, which by its rapid escape causes a rapid commotion in the metal, which is said to *boil*. The action is facilitated by constant stirring. As the carbon diminishes, the action becomes less violent, the iron begins to separate—termed *coming to nature*—in bright spots, which gradually collect together. This reduced iron is subjected to a final heat to separate the fluid cinder. The iron is then collected into balls of about 80 lb. each. These balls are separately lifted by tongs to a table in front of the door and dragged or carried to a shingling hammer or squeezer to consolidate the iron and to remove the slag. The process, therefore, includes the following operations:

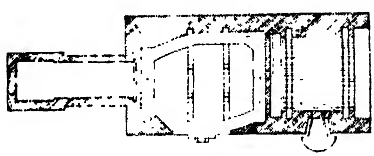
1. Melting the pig iron with or without preheating.
2. Addition of oxidising materials.
3. Removal of carbon by oxidation at high temperatures.
4. Consolidation of the refined iron into balls.

The excellence of the iron produced will depend on the kind of pig iron used and a high temperature during the boil, for if the temperature be too low the reducing action of the carbonic oxide prevents the complete liberation of carbon, and hard, steely iron results. The slag is essentially a silicate of iron containing many of the impurities originally present in the iron, and is termed *tap cinder*.

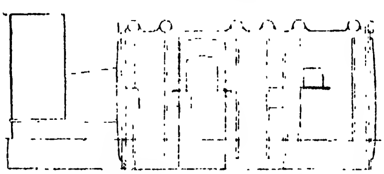
Yorkshire Method of Fettling. The celebrated brands of iron known as Bowling and Lowmoor are made by a process intermediate between that of the dry method and the wet method. Cold-blast pig iron is used. This pig iron is first treated in refineries, the plates of metal thus obtained being reheated and charged hot into the puddling furnace, where a high temperature is used. The metal, being free from silicon, is soon refined, and the balls of iron produced are shingled into blooms or "noblins" about 12 in. square and 2 in. thick. They are then broken, the most fibrous and least crystalline ones being selected as the best iron. These are piled, reheated, and welded into billets, and after again being reheated are rolled into bars. The success of the operation lies in using good pig iron and using only the best of the puddled blooms. It is uniform in quality, and stands several times reheating and welding without deterioration.

Puddling Furnace. The modern puddling furnace [34 to 36] is a single-bedded reverberatory, with a low, flat roof, generally sloping from fireplace to flue. The fire-bridge and the flue-bridge are formed of hollow castings encased in firebrick; the bed is likewise formed of iron plates robatted together; and the sides consist of hollow iron castings. These hollow castings are kept cool by the circulation of air or water through them. The laboratory, or working part, is about 6 ft. long and 4 ft. wide, tapering towards the flue-bridge. The grade area varies from one-third to one-half that of the laboratory. The bed is lined with broken slags, hammer scale, and red oxide of iron, or puddlers' mine, and the sides with bulldog, all being well rammed down, which is termed *fettling*. The whole of the brickwork is cased with side plates of iron, united by flanges and bolts and bound with tie-rods.

34. SECTION OF PUDDLING FURNACE



35. PLAN OF PUDDLING FURNACE



36. ELEVATION OF PUDDLING FURNACE

In Cleveland burnt pyrites (*blue billy*) is used as a fettling. The working door is on the same side as the fire-hole, and is made of firebrick, set in an iron frame; it is suspended by a chain attached to a counterpoised lever. A flue is generally provided for each furnace, and communicates with its own chimney or passes into a boiler for utilising the waste heat. The flue slopes down towards the stack, its sectional area being about one-fifth to one-seventh that of the fireplace. The draught is usually regulated at the top of the chimney by a damper, which is moved by a hanging chain. Two men are required for each furnace—the puddler and the under-hand. About six heats are worked off in 12 hours, the charge being about 4 cwt. to $4\frac{1}{2}$ cwt. The smaller amount refers to grey iron, and the larger to a mixture of white and grey iron. The loss of weight between the pig iron charged into the furnace and the puddled bars is about $1\frac{1}{2}$ cwt. to 2 cwt. per 22 cwt. of pig metal, or from 7 to 10 per cent. The coal required is about 20 cwt. to 22 cwt. per ton of puddled bars. The fettling materials required in a turn of 12 hours are from 6 cwt. to 7 cwt. of bulldog and from 2 cwt. to 3 cwt. of puddlers' mine, in addition to the mill-scale added to the charge.

Fettling. The fettling used in puddling furnaces is of three varieties, depending on the quality of the pig iron employed. It may be classified as *fusible*, *moderately fusible*, and *infusible*. The fusible kind is a silicate of iron containing some magnetic oxide. Hammer-slag is the material used for this purpose. It is regarded as a flux, and the object is to yield a fluid bath into which the grains of iron may trickle and become purified during the melting-down stage, and thus hasten the operation. The

amount of slag required is about one-sixth that of the pig iron used. The moderately fusible kind is used to form the sides of the furnace. It must have a higher melting point than the pig iron, and melt only as the temperature rises, so as to nourish the iron at the later stages of the refining. Bulldog and similar material which contain much ferric oxide are used for this purpose. Bulldog is calcined tap cinder, the calcination being conducted in open heaps or in kilns. This fettling is used for ordinary varieties of iron, but for the best brands of wrought iron a more infusible fettling is employed, such as purple ore or blue billy. The infusible fettling consists of ferric and magnetic oxides, such as hæmatite and pottery mine, used in compact lumps.

Pig Iron for Puddling. White pig iron is sometimes employed for puddling, especially on the Continent, for making sheet iron, as the sheets are less liable to black streaks of slag. White iron works more quickly than grey, as it contains less silicon and manganese, but it gives a smaller yield of puddled iron per ton of pig iron used. The iron chiefly used in England is No. 4, which is a strong and close-grained grey pig-iron. As already mentioned, the fettling used depends on the quality of the pig iron, for if much silicon and phosphorus are present a more infusible fettling is required. Such irons are said to be "hungry." They require more time, more fettling, make the slag too thin, and tend to yield a brittle bar iron. A little phosphorus is an advantage, as it increases the yield of iron and prevents the cinder from getting too thick towards the end of the operation, which would produce red-shortness. The presence of manganese is an advantage, since it covers the carbon, delays its removal, gives greater fluidity to the slag, and helps to remove phosphorus and sulphur.

Special Furnaces. In Anderson's furnace the end and crown of the fireplace are made with a double wall of bricks forming an air passage between. The air in passing through this becomes heated and thus supplies hot air to the furnace; it also serves the purpose of keeping the outside walls cooler. This system is employed in the North of England for ball and mill furnaces. Double furnaces are also employed and consist of two furnaces placed back to back with the dividing wall removed. They have the disadvantages of unequal working of the men and the greater difficulty of working with larger masses of metal.

Mechanical Puddling. Many attempts have been made to introduce mechanical puddling tools in order to lessen the enormous manual labour expended in hand puddling, but with little success. Such tools are arranged so as to be capable of a compound motion over the bed of the furnace. The rabble is supported in a stirrup connected with a lever actuated by overhead mechanism, and by means of a fast and loose pulley can be put in or out of gear at will.

Revolving Furnaces. The best form is that of Danks, which consists of an iron cylinder with conical ends, 4 ft. long and 5¼ ft. in greatest diameter. On the inside are twelve ribs to keep the fettling in position. The cylinder is encircled at each end with a roller-way, which rests on anti-friction rollers. One end is open to the fireplace and the other opens into an elbow-shaped movable flue leading to the chimney. The fireplace is provided with an air-blast pipe placed below the grate, and also small twyers for introducing air at the fire-bridge. The furnace is lined initially with a mixture of crushed ore and lime; then on this there is laid a lining of iron ore and hammer slag, into which, when soft, lumps of hard ore are thrown. The charge consists of pig iron with 20 per cent. of cinder, and as this melts the furnace is revolved, the action being the same as in the ordinary puddling furnace. The process is automatic, and the puddled iron is collected into a large ball ready for the hammer.

Gas Puddling Furnaces. By the use of a gas furnace a higher temperature can be obtained than by using solid fuel. Of such furnaces that of Siemens is one of the best. It is of the ordinary regenerative type, and it possesses the advantage of having the temperatures more under control, and an oxidising, reducing, or neutral atmosphere can be obtained at will.

Treatment of Puddled Iron. This consists of shingling, or hammering, and rolling. Squeezers are also used instead of the hammer. The white balls of puddled iron are taken to the hammer or squeezer to expel slag, to weld the iron into a compact mass, and to confer a shape suitable for rolling. The tilt hammer is used for small work. The helve hammer was universally employed for heavy work, but has been largely replaced by the steam-hammer. This is now used both for shingling and welding. It is a simple direct-acting machine, and takes but little room compared with the cumbrous wheel work of the old helve. The force of the blow in shingling is generally required to be light at first, and with the steam-hammer the force can be varied with the work to be done.

Another advantage is that the hammer always works parallel with the piece under operation, which is not the case with helves, the hammerman having to use thickness pieces to overcome this difficulty. Both sides of the steam-hammer are also accessible for working. It consists essentially of a vertical high-pressure engine with an inverted cylinder. The piston rod is attached to a heavy block or *tup* moving between guides on the inner faces of the standards, which form part of a massive cast-iron framing. The ordinary hammer is double-acting, the steam being exhausted above and below the piston. The hammer varies in weight from 30 cwt. to 60 cwt., but the force of the blow is, to a great extent, independent of the mass of the hammer head.

Squeezers are of two kinds—lever and rotatory. In the former a movable upper jaw is actuated by a crank and connecting rod attached to one end. The rotatory squeezer consists of a

cylindrical casting, the inner surface being studded with teeth. Within this also revolves a cylinder similarly studded and placed eccentrically with regard to that of the outer casing. The ball is carried forward along a gradually narrowing path and compressed to smaller dimensions.

Rolling Mill. The rolling mill for puddled iron contains two sets of rolls—the roughing and the finishing rolls. The roughing rolls are usually 5 ft. long, and about 20 in. in diameter, forming a series of gothic and diamond-shaped grooves between them, diminishing in size from right to left. The larger grooves are gothic shaped and roughened, so as to lay hold of the iron more effectually; the smaller ones are diamond shaped. The distance between the rolls is regulated by the screws and the connection between them is established by means of the cogs attached to the ends. The journals or necks of the rolls run into metal bearings, which are supported in cast-iron frames or housings. The finishing rolls are arranged in housings similar to the roughing pair, but have rectangular channels instead of the diamond grooves. These channels diminish in size from right to left. The two sets of rolls are generally connected together by heavy couplings keyed tightly together. The two rolls of each pair revolve at the same speed, which in the roughing rolls is about 70 revolutions per minute, and in the finishing rolls about 90 per minute when separate.

The bloom of iron is first passed through the largest groove of the roughing rolls, then lifted back over the top roll, turned one quarter round, and passed through the next smaller hole. This operation is repeated until the bloom is reduced to a square bar small enough to enter the flat grooves of the finishing rolls. In this pair the process of reduction is continued until a puddled bar of the desired thickness is obtained. Puddled bars may have ragged edges and a rough surface, and for the production of good bars they are cut up, piled, reheated and welded.

Reheating. Bars and slabs of iron obtained by shingling and rolling puddled iron require to be refined if best malleable iron be desired. They are cut up into short lengths, arranged in faggots or bundles, then reheated and welded by hammering and rolling. The reverberatory furnace for reheating is somewhat similar to the puddling furnace, but the bed is flat, with a slight slope downwards towards the flue, so that the liquated cinder flows out at the flue bottom and is termed *flue cinder*. Ordinary reheating furnaces are relatively inexpensive to erect and are easily worked, but are extravagant in fuel, while the waste due to oxidation is considerable. On this account gas-fired furnaces are largely used with consequent saving of fuel and diminution of oxidation.

Mill rolls are classified according to their shape into:

1. Flat or plain rolls for sheets and plates.
2. Grooved rolls, for bars, angle and channel iron.

For the production of sheets and plates requiring a fine surface chilled rolls are used. The *mill rolls* or *mill train* for rolling merchant iron also consists of two sets—the billeting or roughing pair and the finishing pair. The rolls are provided with tightening and adjusting screws for keeping them accurately in position.

Rolling Small Sections. In rolling small and light sections, which are difficult to keep from distortion while hot, a fore plate and guide jaws are added to the arrangement so as to keep the section straight. In two-high trains revolving constantly in one direction, it is necessary to return the work over the roll after each pass, and this takes up a lot of time so that reversing rolls are often used and reversed at each passing of the metal. The reversal is effected either by reversing the engine itself, or by the use of hydraulic friction, or other clutches and gearing on the engine shaft. For lifting the iron on to the top of the single pair of rolls after a passage through them, so as to return it to the man for another passage, a travelling carriage with forked levers is used for light work. For heavy work an iron table is provided which is raised by a single-acting engine, or by a hydraulic cylinder and ram. Three-high rolls consist of roughing and finishing rolls each of which is a combination of three rolls in its own pair of housings. In this case the mill is generally driven from the middle roll, and arranged so that the middle roll revolves forwards with the lower one and backwards with the top one. The work thus passes backwards and forwards alternately through the upper and lower pair. The various shapes into which the iron is finally rolled are: plates, strips, sheets, bars, rails and various sections. Bars are round, half-round, square, flat, oval, octagon, etc.

Special Sections. Other shapes are made, such as tee-iron, T; angle-iron, L; channel-iron ⊔; aitch-iron, H; Z-iron, etc.

There are three chief imperfections in finished iron; these are (1) *spills*, which are due to enclosed foreign matter, such as slag or oxide of iron; such parts prevent cohesion and cause the metal to peel off after rolling; (2) *blisters*, due to the presence of enclosed gases, such as carbonic oxide; (3) *ragged edges*, due to imperfections in the rolls, or careless working, or it may be due to the iron being deficient in cinder, which makes the metal red-short.

Continued

HEAVY TIMBERING

Flitching and Trussing. Staging, Towers, and Trestles. Timber Bridges. Piles. Cofferdams. Staithes. Crane-work. Methods of Handling Timber. Gates & Fences

CARPENTRY continued from page 4118

By WILLIAM J. HORNER

IN heavy carpentry there is a greater proportion of temporary work now used than formerly, very large timber structures being often erected only to serve as stagings for permanent buildings in iron or stone. At the same time, for large work of a permanent and substantial character, wood is becoming less and less popular, but it is still employed largely in those countries where it is plentiful and cheap. One result of the extensive use of temporary works is that carpentry is often of a simple character, for there is less necessity for elaborate and neat jointing than there is in permanent structures. Bolts, straps, tie rods and castings are used more freely to unite timbers, and less time is spent in making joints more or less intricate in the wood. They are of the simplest possible character, being, as a rule, nothing more than plain butt or lap joints, united by suitable metal connections. In permanent work more regard has to be paid to appearance, and though in many cases the same metal fastenings are employed the finish must be neater and the fitting more carefully done where there is advantage in making it so. Heavy carpentry, however, is comparatively simple work, and largely repetitive when the arrangement and dimensions of the timbers have been decided on. Some selected examples are given in this article.

Flitch Beams. When beams of great strength are required the wood is often *flitched*. This is done by sawing the balk down the middle and bolting it together again with a wrought-iron flitch plate between [**304**]. The plate is about ½ in. thick, and of the same length as the beam, but generally a trifle less in depth, to allow for shrinkage of the wood, and to avoid the consequent projecting ridge of metal. The heart of the wood in such cases is turned outwards, to expose it to the air and ensure thorough seasoning. Even without the metal plate between, rather more reliance can be placed on a balk which has been treated in this way than on a solid one, because there are then no fissures hidden in the interior which would make its actual strength uncertain. Another method less commonly practised is to bolt plates on the outside, enclosing the beam between two plates of metal. Flitch beams, however, and also those in which great depth is obtained by joggling, or serrating balks together, examples of which were shown in **238** and **239** [page 4115], are being less and less employed, owing to the increasing use of rolled iron or steel girders.

Temporary Towers. Timbers of unlimited length and section can also be built up of deals, as shown in **237** [page 4115]. For the support of the Charing Cross Station roof, after the collapse of the tie rod in December, 1905, the uprights were built in this way. Each upright comprised three thicknesses of 9 in. by 3 in. planking, bolted together to break joint. They were about 80 ft. high, and covered an area of 25 ft. There were eight uprights to each tower, and all braced together with horizontals and diagonals. The towers were connected by strong stagings and to the station walls. Timber lends itself better to rapid work of this kind than metal does, for these massive towers were erected in eight or nine days and nights.

Trussed Beams. These are very frequently employed in preference to more massive solid beams of equal strength. Trussing may be done by tie rods within the depth of the beam, arranged to prevent it from sagging in the middle, but usually the truss extends below the timber, as in **305** and **306**. Square balks are thus usually employed sufficiently rigid to resist transverse strain when trussed, the stress being transmitted to the truss rods as tensile forces, and to the struts as compressive ones. A truss with two struts is properly braced by diagonal ties between, as dotted in **306**, if it has to carry a load moving from end to end, but not otherwise. The reason is that the tie rods tend to straighten out, and bend the beam unless counterbraced. The depth of beam may sometimes be made strong enough in itself to resist this tendency, but that would not be practicable in long spans. If there is no moving load, but a dead one imposed, no counterbracing is necessary.

Trussing may be an alternative to the employment of diagonal struts from the posts which support the ends of a beam, but in many cases strutting is not practicable, as, for instance, in the beams of an overhead travelling crane, which must be free to move along its gantry.

In short spans, the beam is trussed with a single support or strut in the middle [**305**, A]; in longer ones support is given at two intermediate points [**306**, A A]. The struts are usually castings, but are sometimes made of timber. Castings, B B, are usually necessary also on the ends of the beam, having lugs to receive the screwed ends of the tie rods, and provide a seating for the nuts in tightening up the rods.

The carpenters who prepare the timbers also fit the castings and complete the truss. The recesses in the castings are properly ⅛ in. or ¼ in. less than the timber sections to allow a little for possible shrinkage and fitting. They are tapered to drive on tightly, the timber ends are smeared with thick, white lead paint, and the shoes driven on with heavy, long handled mallets. In many cases a single tie rod will be fitted in the centre of the beam instead of two, as shown in **305** and **306**, flanking the beam. Then diagonal

holes have to be bored with an auger to pass the bolts through. The threads of the bolts must never measure less in diameter at their *roots* than the diameter of the tie rods.

Built-up Girders. Instead of trussing a beam with tie rods and struts, its depth may be increased by separating it into upper and lower members, and in place of solid material between connection is made by diagonal braces [**307**]. This increase in depth gives enhanced rigidity without corresponding increase in weight. The material, in fact, is removed from the middle or neutral plane of the beam, where it is of little or no value, and concentrated along the planes of greatest stress. Diagonal bracing and vertical posts are usually associated in this connection of top and bottom rails, but the diagonals are the most essential; the verticals alone would be useless. Often the verticals are of iron rod, while the horizontals and diagonals are of wood [**307**], but frequently all the members are of timber.

Trussing and strutting are, of course, necessary chiefly for horizontal timbers which would otherwise not be sufficiently rigid to resist stresses which would sink or fracture them about the centre. The alternative is to support them at frequent intervals throughout their length by perpendiculars. This is not always practicable or advisable. As vertical timbers are seldom subjected to direct transverse stress as horizontal ones are, they require lateral support to bring them into the condition of short columns. The methods of doing this necessarily resemble the strutting and trussing of many horizontals, for diagonals are required in both cases. It is true that in a narrow structure like a ladder diagonals can be dispensed with, but if length, width, and stability were the only considerations, a much smaller number of transverse members would be used, and equal stability would be attained by diagonal pieces either fitting between them or over all. If we take a framework that is wider, or more nearly square in its proportions [**308**], it is obvious that diagonal braces from corner to corner will tie the frame more directly and securely than a far greater amount of material inserted in the form of transverse bars. Diagonal bracing, therefore, is always employed in structural work between horizontal and vertical members. The result is that the main timbers of the structure are tied at so many points that, no matter what their length or the size or form of the structure may be, stresses produce no alteration in form, for the diagonals come at once into play as rigid ties and struts.

Looking at **309**, which is a typical arrangement of timbers in a tall structure, each vertical member would, if unstayed, become bent or broken by a vertical load as certainly as though it were stressed by direct forces acting laterally. But the diagonals and horizontals in effect shorten the lengths, bringing the structure into a condition of superimposed short columns, which would resist bending, the effective length of the columns being A A, even without the horizontals, which resist tendency to bending midway between the union of the diagonals. In **310**, additional rigidity is obtained by the outstanding struts. These are equally suitable either for a vertical or horizontal structure.

Trestles. Trestles are structures placed at intervals to support overhead roads, railways, bridges, or platforms. They are built up of verticals, horizontals, and diagonals, similar in principle to **309**, but to give increased stability on their base they generally taper, as shown in **311** and **312**. Their design may vary considerably. The two examples given are suitable either for temporary or permanent works, and are typical of many American bridge trestles. Some arrangements of timbers for temporary staging are illustrated in the article beginning on page 1170.

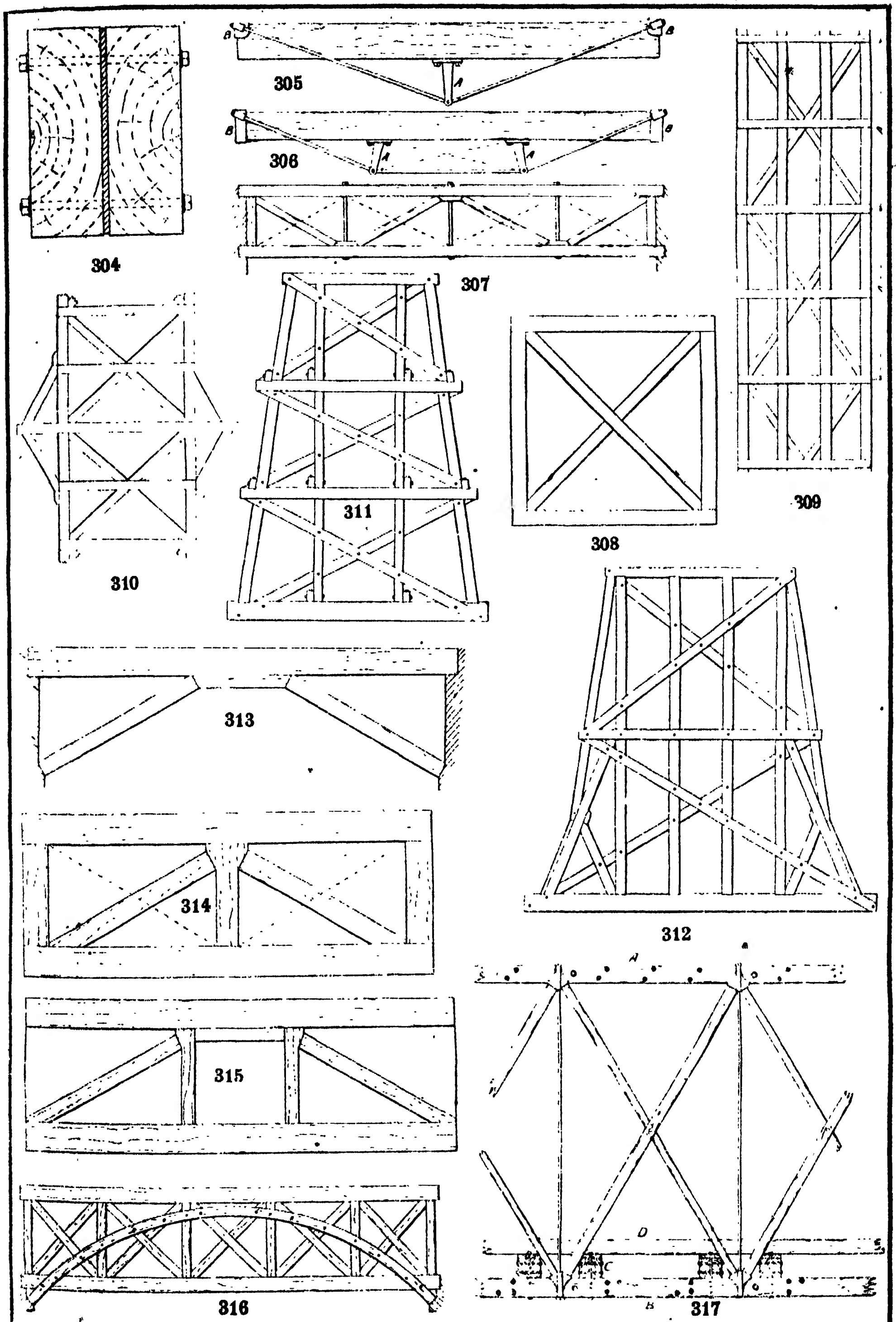
In permanent structures similar arrangements are adopted, but more carefully and neatly designed and executed. Instead, for instance, of bolting braces or transverse members on to surfaces, they would be stub tenoned between in the same plane. Or, instead of securing joints by driving in dogs or spikes, bolts, coach screws, or straps would be used under similar circumstances.

Plain butt joints are very common in temporary work, but not in permanent structures, where stub tenons, joggles, cogs, notches, or dowels are employed to prevent lateral movement of the parts quite independently of the means which hold them together.

Bridges. Bridges entirely or partly of wood are common, especially in America, where timber is the material most readily available. Timber is, of course, more suitable for very small bridges than for large ones. Foundations of stone or brick for a wooden bridge are more permanent than wood piles. If a bridge runs over a river, it is cheaper to drive piles for intermediate supports, but masonry can be employed without difficulty for buttresses. The bridge itself is always trussed in some way to give it sufficient strength to span from one support to another, and to carry the load required. The trussing may be done either above or below the roadway, or both. Fig. **313** shows a horizontal bridge timber supported by struts from the buttresses.

This, of course, is suitable only for a very short span, but strutting of more complicated character is often practised in addition to trussing. Fig. **314** shows a simple truss of the king post type suitable for a short span, or, by inserting a series of posts and struts, the span might be extended. It might also be further increased in rigidity by diagonals or counterbraces in the opposite direction as dotted. Fig. **315** is a truss of the queen post type, suitable only for a short span; **316** is suitable for long spans. The bridge sides are built up of a series of posts and diagonal braces between the upper and lower *chords*, and this may be further stiffened by an arched rib bolted to each side as shown.

Heavy timber work has probably never been so fully developed in any country as in the United States and Canada, where hundreds of railway bridges have been built of that material. Timber was, and is, superabundant and cheap, and the sawmills convert it into squared sections of all sizes at low cost. But for this fact many of the primitive railways in sparsely populated



HEAVY TIMBERING

304. Flitch beam **305** and **306.** Trussed beams **307.** Built-up girder **308.** Braced frame **309-312.** Examples of trestle work **313-316.** Methods of imparting rigidity to bridge timbers **317.** A Howe truss for a large timber bridge

districts could not have been constructed. Though the timber bridges and viaducts are not long lived, neither are those of steel. The first part to decay is the bottom chords, or *booms*, which have to be repaired or renewed in about from seven to ten years if unprotected from the weather. But if covered in they last for about thirty years. Timber has been used for spans of over 200 feet. The ingenuity which has been displayed in building up these spans is an interesting study in how to obtain maximum strength with materials in themselves relatively weak, and with the simplest kinds of joints. These trestle bridges are constructed of trusses with triangular panels, one example of which is shown in **317**, being a Howe truss supported on trestles, or towers, some of which are of great height. One section of a trestle is a repetition of other sections, and one panel of a truss is like another, so that the work is repetitive. Cast and wrought iron enter into the construction only at the joints and fastenings. As the sticks of timber do not exceed from 50 to 60 ft. in length, a number of fish joints, or *clamp* joints, as they are termed, are necessary in making up the total lengths. They are made to break joint at long intervals, and iron or wooden clamps are employed to tie them. Figs. **317** to **324** show these arrangements, and also the method of building up the top and bottom booms or chords, while their position in the bridge truss is seen in **317**, which shows a panel, and **318** a cross section through the bridge, including the rail track.

The top and bottom chords, A B, are each built of four rows of jointed balks, breaking joint as already mentioned, so that the joints in one row or length come several feet away from those in the one adjacent. They are not in lateral contact, but separated about 2 in. [**319** and **320**], which gives spaces for the clamping plates while avoiding having to notch the timbers deeply. To key these open balks together into a practically solid mass packing blocks [**319** A] are inserted at intervals, each set arranged in line across, and bolts are inserted through them and the timbers, as shown in **319**. To ensure a tight fit these packings are tapered edgewise, being about ½ in. narrower at the bottom than at the top, and are thus driven in firmly. The grain runs in the same direction as that in the balks, so that they will not loosen by shrinkage.

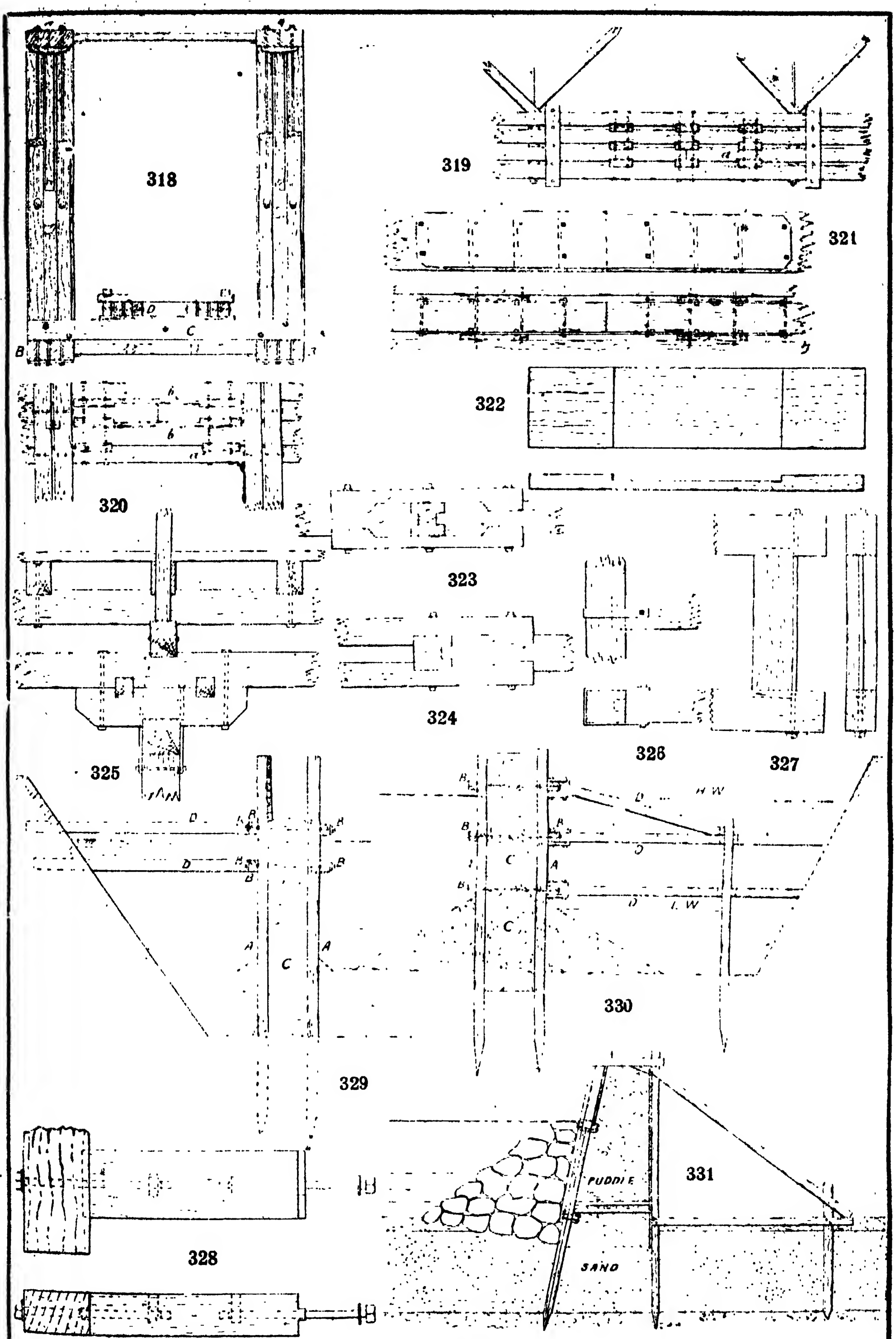
When end joints meet they are variously secured by iron or wooden clamps. If of iron, ½-in. plates are used with iron joggles riveted or bolted across them to enter into grooves in the timber [**321**]. The plates fit on opposite faces, and bolts pass through the whole. If wood clamps are used they are notched to enter into notches in the main timbers on each side of the joint. Two wooden clamps are shown at **320** *bb*, and a clamp separately in **322**. Figs. **323** and **324** show similar clamps uniting horizontal with vertical members. The top and bottom booms are identical in construction, differing only in dimensions, but the bottom booms are connected by cross bracings, and they carry heavy cross timbers [C, **317** and **318**] to receive longitudinals, D, upon which the rail sleepers are laid. The top and bottom booms are connected by the diagonals [**317**], which are stepped against castings through which vertical tie bolts pass. All this notching and fitting seems tedious, but in America the sawmills are erected in the forests and in the course of the railways, and woodworking machinery is greatly developed.

Jointing and Fastening. Fig. **325** illustrates the joggling of heavy balks, involving but a small amount of work, yet being absolutely secure when bolted; **326** shows a stub-tenon and strap connection. The latter makes a very secure union between timbers which cannot be conveniently held by other means. Fig. **327** is a case where a long bolt and stub-tenon joints are suitable. If the timbers were of very large section, and great strength was required, more than one bolt would be employed. Bolt holes slightly weaken the timbers through which they are put, while straps round the outside have the contrary effect. Fig. **328** is a stub-tenon joint similar to the two preceding ones, but instead of holding the parts together by a strap or long bolt comparatively short bolts are fitted into the tenoned ends. This might be done either for neatness or when the tenoned member is too long for a through bolt to be suitable. Recesses are bored for the nuts in one of the faces of the timber, and the bolt holes are bored to suit. The recesses are generally plugged after the nuts are in, and the bolts have to be screwed into their nuts.

Work Involving Piles. Piles are very often used for foundations both in temporary and permanent work, and both on land and under water. The piles commonly used are balks of firwood, but the best are of greenheart or elm, because more durable. Piles are pointed, and usually sheathed in iron to enable them to penetrate. An iron ring is also fitted round their tops to prevent splitting when driving. They are driven by a weight called a monkey, which slides in vertical guides, and is hoisted and allowed to fall by gravity repeatedly on the head of the piles.

Piles for the foundations of structures are spaced according to the weight they have to carry. Those for cofferdams and caissons, which have to be made watertight, are driven closely side by side, and the joints filled with clay or other packing when necessary. This is called *sheet piling*. Piles are braced and tied together after being driven, by *waling* pieces, and the heads are sawn level where necessary. Often piles are driven at angles instead of vertically, according to the character of the structure which they have to support. On land large horizontal balks are sometimes laid to bed the verticals on instead of driving piles into the ground. For permanent structures a concrete bed is often made, the bed itself being laid on the tops of piles, which are driven flush with the ground and tied together by a horizontal framework.

Cofferdams. These are constructed of double rows of piles, which are driven in close contact, usually with sawn edges. To keep them in line they are connected by horizontal waling pieces at intervals of 4 ft. or 5 ft. Short bolts



HEAVY TIMBERING

318-324. Details of large timber bridge **325.** Joggling of heavy balks **326.** Timbers united by stub tenon and strap **327.** Timbers united by long bolt **328.** Inserted bolts **329-331.** Examples of strutted dams

pass through waling pieces and piles. The water is then pumped out from the enclosed space, and well-tempered puddle clay is filled in and rammed down in layers. Thus a watertight wall is built, within which, the water having been pumped out, excavation can be carried on in the dry. In plan view a cofferdam may be of any required outline, circular or rectangular, or simply fulfil the function of a dam of sheet piling to enclose an area from which, without such protection, water might be expected to burst out on works in progress. When a dam is not a self-contained structure it is often strutted. Figs. **329 and 330** show dams of this kind, the struts being combined with the dam. In these illustrations, A A are the timber piles shod with iron, connected by waling pieces, B, and fastened with bolts; C is the clay puddle. In both cases the dam is shown in proximity to an old dock wall. The struts, D, take the external pressure. In one case they are simply driven into the old wall. In the other they are connected to a row of piles tied together with horizontal timbers. The cofferdam often takes the form of a strong sea barrier to keep out the ocean when tidal docks are in course of construction. In some cases they themselves have to be protected by groynes. In such work the construction has to be very strong. The seaward piles are then often driven at a considerable angle to broaden the base, and the sea face is protected with rubble. The inner face is tied to a row of piles. Timbers are often creosoted. Fig. **331** shows a section through a barrier of this class.

Staithes. Some fine examples of heavy timbering are found in the staithes on Tyneside and other Northumbrian ports. They are coaling stages along which the old chaldron waggons or the modern trucks are run out by gravity over the water for the shipment of coals. They carry loading cranes if fixed, or gantry or travelling types. The staithes are built on piles. As they go out from the banks into water deep enough to allow vessels to come under the cranes the length of the piles becomes considerable next the vessel's side. At the shore end the timbering is plain, but as the staith goes out farther the piles are put closer together; sometimes two or more timbers are bolted together or single piles are heavily fished. Struts and diagonal bracings are introduced with horizontal timbers, and bolts and iron straps reinforce the various joints. Some typical constructions are shown in **332** and **333**. The former is a staging built on piles and tied back to other piles driven in higher up the slope of the river bed. The top horizontal members carry the flooring; **333** is a face or end view of one set of timbers in a staging. A A are double longitudinal balks that tie the several sets together. The general arrangement of other horizontals and of diagonals is clearly shown.

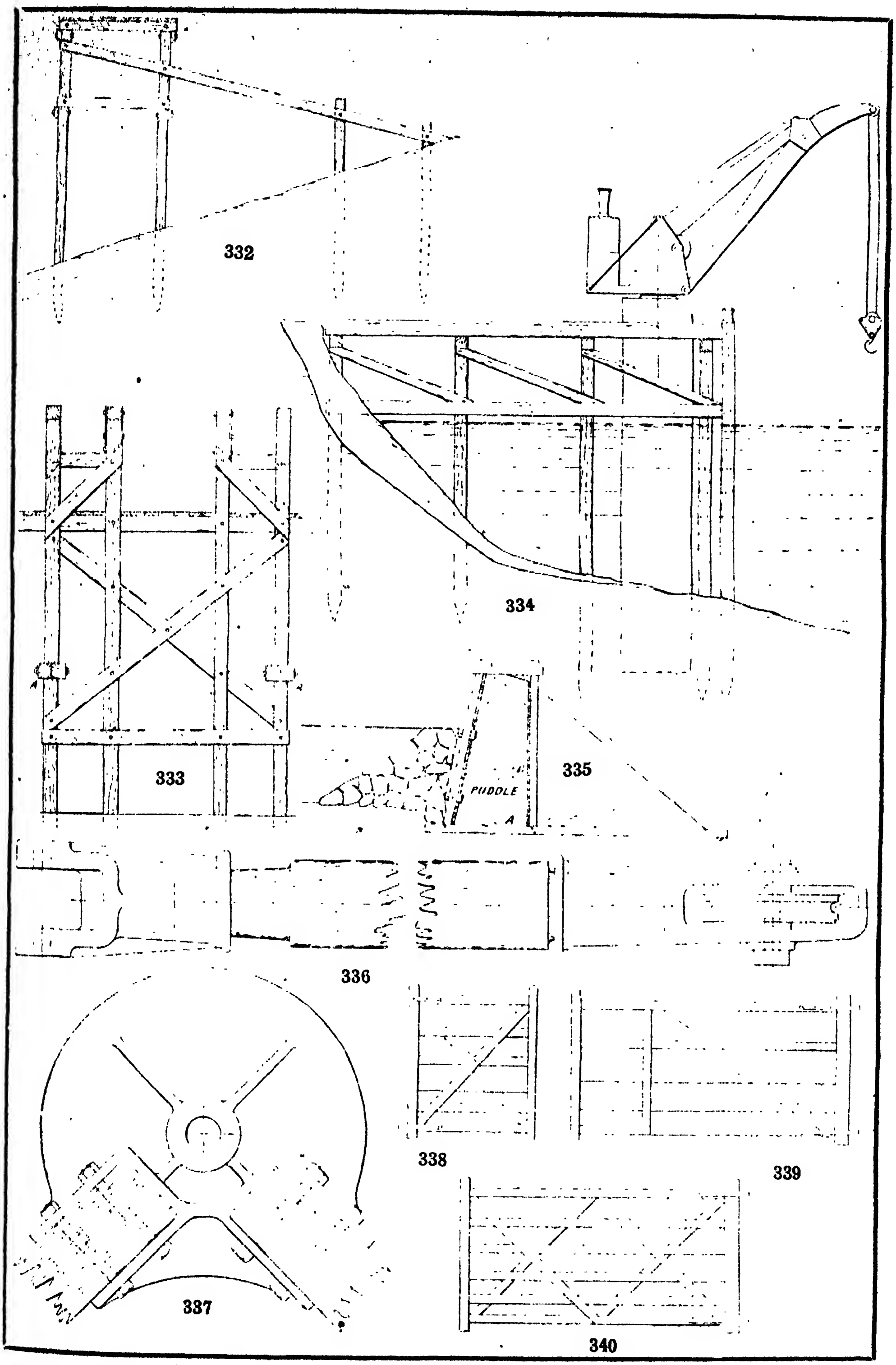
Fig. **334** shows a staith end or staging carrying a steam crane. The timber work is for the staging only, the crane being carried on a deep foundation cylinder of cast-iron rings bolted one on top of another with internal flanges. This is more rigid than timber foundations for cranes doing heavy service. Fig. **335** illustrates an alternative to piling when a rocky bed is encountered into which piles cannot be driven. Balks, A, are laid upon the rock and bolted down with lewis bolts, or retained with rubble thrown on top. These then form ties between the uprights and the diagonal struts, which form stays to the uprights against the pressure of the water. The interior between the uprights is filled with clay puddle, and the sea front is protected with rubble or boulders.

Dock Gates. Dock gates are often built of timber. Greenheart is the best for this purpose, because it resists better than any other the attack of the *teredo navalis*. Another advantage is its great weight. The difficulty is to obtain balks large enough, dimensions of as much as 20 in. square being sometimes required for ribs and heel posts.

Crane Work. In the manufacture of some classes of cranes there is a good deal of heavy timbering employed. Many cranes for foreign and colonial service also are made cheaply by purchasing the necessary ironwork, gears, etc., in England, and building timberwork in the country where required. The principal elements in which timber is frequently used are jibs, the beams for some overhead travellers, the gantries; the masts, guys, and sleepers of derricks, the poles of sheer-legs, and sometimes the trucks of travelling cranes used in quarries and on wharves. All these, without exception, have some metal fittings in the forms of castings and forgings, and as these have to be fitted accurately into their places on the crane to which they belong the carpenter in the engineer's works is somewhat of a specialist.

Some parts are fitted by driving only. Among such are the socketed feet and heads of timber jibs [**336**]. The ends of the stock are sawn nearly to size, and then eased with chisels and planes. The castings are tried from time to time, being driven on with a sledge, the easing being thus done tentatively. When they are within about $1\frac{1}{2}$ in. or 2 in. of bedding, the surfaces are well smeared with thick white-lead paint and the final driving done. The castings are not driven right home, but only to within about 1 in. of the shoulder. This allows for a little further driving subsequently, as at the right hand of **336**, when the timber has shrunk. At the left hand the timber is seen partly out of its casting. Many castings fit around three sides only of timber, leaving one side open. Driving is still practised, but security is ensured by means of bolts [**337**]. In some cases bonds are shrunk on the ends of timber, as in pile tops, ends of gantry beams, but this practice is of limited use.

Tools and Machinery Employed. Among hand tools the two-handled cross-cut, the ordinary handsaw, the auger, the chisel, and axes and adzes are the chief cutting tools employed. The timber in heavy carpentry is not usually planed. Where a considerable amount of work has to be done, preparation of each piece of timber by hand is slow and expensive. The parts, therefore, are either prepared before they leave the sawmill, or suitable machinery is brought to the place where the



HEAVY TIMBERING

332-334. Examples of staithes **335.** Barrier erected on horizontal balks instead of piles fitted into castings **338-340.** Field gates **336** and **337.** Crane timbers

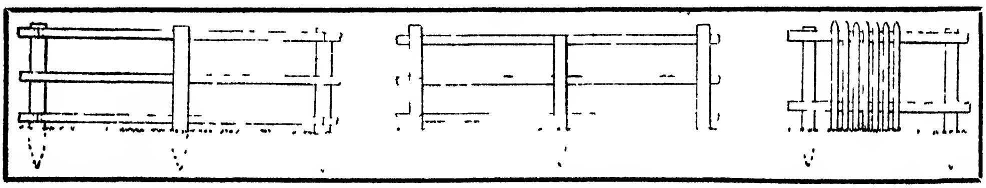
work is being erected. In the latter case the machines are usually of a different character from those which would be installed for permanent use in a shop or sawmill. A small reciprocating saw of the three-feller type, for instance, would be brought in preference to a large band or circular saw. Steam power would be obtained from a portable boiler. Light machines, perhaps worked by hand, would be used for boring bolt-holes, or a combination machine for boring, both horizontally and vertically, and cutting rebates, half laps, and mortises and tenons. If a great majority of either of these classes of work was required, machines specially for it would be employed.

Appliances of various kinds are necessary for handling heavy pieces of timber. Transportation to the locality is effected by railway or on timber carriages drawn by horses. Very large balks are carried by the latter method suspended beneath the axle of a large two-wheeled carriage; smaller ones on a four-wheeled carriage, the distance of the back wheels from the front being adjustable by sliding them along the pole which forms the connecting body. Transportation for short distances at the place where the work of erection is proceeding is effected by travelling cranes, hauling apparatus, derricks, crowbars and rollers, and numerous other means. Lifting is done with ropes or chains round the timber, or wrought-iron timber clips, which grip it tightly as hoisting power is applied. These are also used to assist in turning very heavy balks. Hoisting may be done by cranes or crabs, or by hand tackle worked through a block attached to any suitable support overhead.

Railway Carpentry. A good deal of heavy work is done in railway shops, but it is almost wholly that of machinery—sawing, planing, tenoning, grooving; everything, in short, but the actual putting of parts together. The explanation of this is that it is a class of work in which similar parts jointed similarly are constantly required, and when this is the case machinery for doing the work is always infinitely more expeditious and cheaper than hand methods. In many cases hand work on a large scale would be out of the question, and if the employment of machinery were not possible the work would have either to be done in a much simpler and more primitive style or to be left undone. The woodwork in railway shops consists chiefly in the construction of rolling stock. Oak is the wood chiefly employed.

Field Gates. These are a light class of carpentry. Examples of gates are shown in 338 to 340. Heavier and more ornamental varieties are often used for entrances to parks and villas. Fig. 338 is a wicket gate. The diagonal brace in this and in all other gates slopes from the lower part of the hinged or hanging post to the upper part of the front post. A counter brace as dotted may be added, but the brace in the other direction is the most essential. The hinge post is stouter than the other, and the hinges extend some distance along the rails, packing pieces being put on the latter, if necessary, to form a level bed to attach the hinge to. The rails are mortised into the posts, and are generally spaced farther apart at the top than at the bottom of the gate. Fig. 339 is an ordinary field gate, which, when open, leaves a clear 9 ft. way, the gate itself measuring about 8 in. more than that. The brace in this case is made to support the gate more effectively by carrying it up to a point some distance short of the front post and adding a vertical bar, so that all the rails are supported at this point, and the overhang beyond is a trifle. In 340 two braces are employed in each direction. The two main ones slope as in the previous examples. The first goes from the foot of the hinge post to the middle of the top rail, and the second from the middle of the bottom rail to the top of the front post. These braces might be still further increased in number with beneficial results, except that the gate, being made heavier, would strain the hinges more. Often the top hinge is made longer than the bottom one, because the strain on the top connection is tensile, while at the bottom it is compressive.

Fences. Examples of these are shown in 341 to 343. In all cases posts have to be inserted in the ground to support the rails. The posts are generally about 6 ft. apart, and the rails in 12 ft. lengths, so that the stability of the fence is increased by alternating the joints. Rails may be nailed to the sides of the posts, as in 341, or mortised in with scarfed ends, as in 342. In the latter the ends are supposed to be mortised into thick posts and nailed to the intermediate post, which is of smaller dimensions. Fig. 343 shows how pales may be attached to the rails. When strained wire is used instead of wood rails, the end posts have to be substantially strutted to resist the strain. Where durability is important, creosoted or kyanised wood should be used for gates and fences.



341. Fence rails nailed to posts   342. Rail ends scarfed to fit in mortises   343. Palings nailed to rail

CARPENTRY *concluded; followed by* FIREPROOF CONSTRUCTION

Continued from page 4512

ITALIAN

Continued from page 4505

By Francesco de Feo

IRREGULAR VERBS
Second Conjugation
Verbs in **ere** (short)

Of the following verbs, only the irregular forms will be given.

Conòscere, to know (I know somebody)
Past Def.—Conobbi, conobbe, conòbbero.
Past Part.—Conosciuto.

Conjugate like *conòscere*: *riconòscere*, to acknowledge, to recognise; *disconòscere*, to deny.

Crèscere, to grow
Past Def.—Crebbi, crebbe, crèbbero.
Past Part.—Cresciuto.

Conjugate like *crèscere*: *accrèscere*, to increase; *decrèscere*, to decrease; *rincrèscere*, to be sorry.

Assìstere, to assist; *consìstere*, to consist; *desìstere*, to desist; *esìstere*, to exist; *insìstere*, to insist; *persìstere*, to persist; *resìstere*, to resist; *sussìstere*, to subsist, are all irregular only in the past participle, which, instead of ending in *-uto*, ends in *-ito*: *assistito, consistito, esistito*, etc.

Esìgere, to exact; *redìgere*, to redact. These two verbs are regular, except in the past participles: *esatto* and *redatto*.

Nàscere, to be born
Past Def.—Nacqui, nacque, nàcquero.
Past Part.—Nato.

Conjugate like *nàscere*: *rinàscere*, to be born again.

Nuòcere, to hurt
Ind. Pres.—Nòccio, nuoci, nuoce, nociamo, nocete, nòcciono.
Past Def.—Nocqui, nocque, nòcquero.
Subj. Pres.—Nòccia, nòccia, etc.
Past Part.—Nociuto.

Bere (*bèvere*), to drink
Ind. Pres.—Bevo, bevi, beve, beviamo, etc.
Imperf.—Bevevo, bevevi, etc.
Past Def.—Bevvi and *bevetti, bevesti, bevve*, and *bevette, bevemmo, beveste, bevèttero* and *bèvvero.*
Future.—Beverò and *berrò*, etc.
Subj. Pres.—Beva, beva, etc.
Gerund.—Bevendo.
Past Part.—Bevuto.

Piòvere, to rain
Past Def.—Piòvve.

Ròmpere, to break
Past Def.—Ruppi, ruppe, rùppero.
Past Part.—Rotto.

Conjugate like *ròmpere*: *interròmpere*, to interrupt; *irròmpere*, to rush in; *proròmpere*, to burst out.

Essere, to be
[See pages 2194 and 2484-5.]

Note. When the past definite is irregular, only the first and third person singular and the third person plural are irregular. Thus:

Conòscere—Past Def.: conobbi, conoscesti, conobbe, conoscemmo, conosceste, conòbbero.

Piacére—Past Def.: piacqui, piacesti, piacque, piacemmo, piaceste, piàcquero.

When the future is irregular, the conditional is also irregular. Thus; *Bere—Future: berrò, berrai*, etc.; *Condit.: berrei, berresti*, etc. *Vedére—Future: vedrò, vedrai*, etc; *Condit.: vedrei, vedresti*, etc.

Exercise XL.

1. Dove hai conosciuto quel signore? 2. Lo conobbi a Nizza l'anno passato. 3. Riconosco il mio torto e le domando scusa. 4. La mia stima per il gióvine marinàio crebbe di molto, quando lo sentii lodare in tal modo dal suo capitano. 5. Si sa dove si è nati, ma non si sa dove si muore. 6. Egli nacque di genitori poverìssimi, ma con l'assìduo lavoro è riuscito a mèttere insieme una discreta fortuna. 7. Essi hanno insistito tanto che ho finito per cèdere. 8. Alla fine del pranzo tutti bèvvero alla salute degli sposi. 9. I ladri rùppero i vetri di una finestra a pian terreno, e penetràrono nella casa. 10. Oggi ho assistito a una scena terrìbile; un povero muratore è caduto e si è rotta una gamba.

RELATIVE PRONOUNS

The relative pronouns are:

chi (*kee*), he who, she who
che (*keh*), who, whom, that, which
il quale, la quale, who, whom (sing.)
i quali, le quali, who, whom (plur.)
cui (*koò-ee*), whom (compl.)
quanto, all that which
quello che, ciò che, what
chiunque, every one who

1. (*a*). *Chi* never refers to a preceding word. It means *colui che, colei che*; and also *qualcuno che* (someone who). Examples: *Chi ben comìncia è alla metà dell'opera*. Well begun is half done (literally: He who begins well is half way through his work). *Troveremo chi ci mostrerà la via*. We shall find someone who will show us the way.

(*b*). *Chi . . . chi* has a partitive meaning. Example: *Chi dice una cosa e chi un'altra*. Some say one thing and some another.

(*c*). In exclamative, interrogative, and dubitative propositions *chi* means *qual persona*. Example: *Non so a chi rivolgermi*. I don't know to whom to apply.

(*d*). *Chi* in a conditional construction may be used absolutely with the meaning of *se uno* (if one), *per chi* (for him who). Example: *Questo, chi lo vuol sapere* (= *se uno lo vuol sapere*; *per*

chi lo vuol sapere), *appartiene a me.* This (if anyone wishes to know; for him who wishes to know) belongs to me.

2. *Che* is used both as subject and object, and refers to any preceding word, masculine or feminine, singular or plural. Examples: *Lo scolaro che studia,* The pupil who studies; *I libri che avete comprati,* The books that you have bought. It may refer to a whole proposition, and then it is generally preceded by the article. Example: *Gli era saltata la fantasia di farsi frate,* (*il*) *che a quei tempi era il ripiego più comune per uscìr d'impicci,* The fancy had come into his head to turn friar, which in those times was the commonest device for getting out of difficulties. *Che* may also be used instead of *in cui, per cui, da che.* Examples: *Il giorno che* (*in cui*) *ti vidi.* The day when (in which) I saw thee. *Ecco la ragione che* (*per cui*) *non son venuto,* That is the reason why (for which) I did not come. *Sono due anni che* (*da che*) *è partito,* It is two years since he went away.

3. *Il quale, la quale, i quali, le quali* are used like *che,* but are not referred to pronouns expressing things: *fate quello che vi dico* (and not *quello il quale vi dico*). Do as (what) I tell you.

Il quale, la quale, etc., must be used before *nouns* (for example, *le quali case,* and not *che case*), after a preposition (*la scàtola nella quale,* and not *in che*), and where *che* might be ambiguous (*I figli della signora, i quali ho incontrati,* and not *che ho incontrato,* because *che* might be referred to *signora*).

4. *Cui* is generally used instead of *il quale,* etc., after a preposition for both genders, and in the singular as well as in the plural. Examples: *Il motivo per cui io venni,* The reason why I came; *La persona di cui le parlai,* The person of whom I spoke to you; *L'amico da cui mi aspettavo un favore,* The friend from whom I was expecting a favour. Placed between the article and the noun *cui* means "whose." Example: *È un giovane i cui costumi* (*i di cui costumi* would be incorrect) *sono degni di lode,* He is a youth whose manners are deserving of praise.

5. *Chiunque* means "any person who," and is used like *chi.* Example: *Ammettete chiunque venga,* Admit whosoever comes. It may be used also as an indefinite pronoun. Example: *Questo lo sa fare chiunque,* Anyone can do this.

EXERCISE XLI.

1. La casa della quale le ho parlato si trova in via Roma. 2. Chi non sa ubbidire non sa nemmeno comandare. 3. Fate ciò che vi ho detto, e vi troverete bene. 4. Dobbiamo amare chi ci ama, ma non dobbiamo odiare chi ci odia. 5. La ringràzio delle tante prove di amicizia che mi ha sempre mostrate. 6. Fàtemi vedére che cosa avete in tasca. 7. Gli ho restituito il danaro che mi prestò. 8. La signora che avete veduta è la moglie del nostro padrone di casa. 9. L'òrdine che mi avete dato è stato puntualmente eseguito. 10. Ecco quanto so, non posso dirle di più. 11. Il vècchio agricoltore pone il seme dell'àlbero, i cui frutti vedranno i figliuoli e nipoti.

CONVERSAZIONE

Dove volete andare? Non vedete che piove.

Se aspettiamo che finisca di piòvere, ho paura che resteremo qui tutta la notte.

Bisogna avèr pazienza; chi sa che non càpiti una vettura vuota.

Sarebbe una vera fortuna; ma chi volete che venga fin quassù con questo tempàccio?

Intanto si gela. Se si potesse fare un bel fuoco!

Lasciate fare a me che son nato e cresciuto nelle montagne.

Senti come tuona! Meno male che abbiamo portato abbastanza viveri.

Beva un po' di questo vino, vedrà che non sentirà più il freddo.

C'è da fumare?

Ce n'è per una settimana.

È quello che ci vuole: fra una sigaretta e l'altra il tempo passerà presto.

INTERROGATIVE PRONOUNS

The interrogative pronouns are: *chi?* who? *di chi?* whose? *che? che cosa?* what? *quanto-i a-e?* how much? how many? *quale-i?* which? what?

1. *Chi?* means "which person?" (sing.) but when used with the verb *èssere* it is also plural. Examples: *Chi vi manda?* Who sends you? *Chi sono quelle signore?* Who are those ladies?

2. *Che?* means "which thing?" Example: *Che fate?* What are you doing? As an adjective it is masculine and feminine, singular and plural. Examples: *Che libro vuole?* Which book do you want? *Che libri leggete?* Which books are you reading?

3. In familiar language *cosa?* is used as an interrogative pronoun instead of *che cosa?* Examples: *Cosa dite?* What do you say? *Non so cosa voglia dire,* I do not know what he means. The past participle referring to *cosa* is always in the masculine: *Cos' è accaduto?* What has happened? *Cosa ha fatto?* What have you done?

4. *Quanto?* expresses the English "how long?" Example: *Quanto dobbiamo aspettare?* How long must we wait?

The interrogative pronouns are often strengthened by *mai, e.* Examples: *Che dici mai?* What are you saying? *E cosa importa?* And what does it matter? Questions are answered in Italian by *sì, già, certo,* etc., in the affirmative, and by *no, ma che,* etc., in the negative.

The English: Are you? Are you not? Do you? Do you not? Did you? etc., which accompany a question, are rendered in Italian by *non è vero?* (is it not true?). Example: *Lei viene con noi, non è vero?* You are coming with us, are you not?

EXERCISE XLII.

1. Quanto ha pagato questo cappello? 2. Di chi è questo portafogli? 3. Chi ha portato questo bagàglio? 4. Quel signore è un inglese, non è vero? Qual' è il treno per Roma? 6. Cosa hanno comandato per il Natale? 7. Cosa hanno questi ragazzi? 8. Chi è costui? 9 A quale stazione ci fermeremo? 10. A chi avete dato il biglietto? 11. Che cosa ha detto suo padre? 12. Di quale signora parlate?

13. In che anno siete nato? 14. A che pensa sua cugina? 15. Chi ha domandato di èssere ammesso?

KEY TO EXERCISE XXXV.

1. When I entered they had already gone. 2. I am pleased that you have succeeded in this affair. 3. The performance has lasted more than two hours. 4. I have fallen, and have hurt myself. 5. I am not sleepy; I have slept all day. 6. I am waiting for my brother; he was to have come by the seven o'clock train, and I wonder that he has not yet arrived. 7. If you had come ten minutes earlier, you would have met Mr. N. 8. A man-of-war has sunk in the Baltic. 9. A Japanese torpedo-boat has sunk two Russian ships. 10. I have wandered about all day without settling anything.

KEY TO EXERCISE XXXVI.

1. Put them aside; we shall make use of them when we have need of them. 2. That is not correct. 3. This man is so full of himself that it seems that all the world belongs to him 4. This is an author of great merit; that is a most genial poet. 5. I dare not speak openly, because I fear to be misunderstood by these, and combated by those. 6. You do not know what you are talking about. 7. I don't know how things will end; for my part, I do not see clearly in this business. 8. Here are two bottles large enough; in this one we will put the wine, and in that one the water. 9. Do not speak to me of those people; they do not deserve to be helped any longer. 10. Lewis aimed rather at avoiding the blows of his enemy, and at disarming him, than at killing him; but the latter desired his death at any price. 11. That woman speaks only out of envy; it is better not to listen to her. 12. Those who make most noise (literally, shout more) are always right in this world. 13. The prize will be given to him who has deserved it.

KEY TO EXERCISE XXXVII.

1. I am glad to see that you are well. 2. I do not remember you, but it seems to me that I have seen you somewhere. 3. I had the pleasure of knowing you in Rome two years ago. 4. When in the country we are used to taking a long walk before breakfast. 5. Fear nothing; I will think of your future. 6. I am sorry to be obliged to speak to you in this way. 7. My head aches; it will be better for me to remain in the house. 8. It had seemed to me that they had rung the bell. 9 Till now we have always done as you liked; now, it seems to me that you should do as we like.

KEY TO EXERCISE XXXVIII.

1. That poor man must have put together a fair sum, because everyone has given him something. 2. I am speaking generally, and I should not like anyone to consider my words as referring to him. 3. Iniquity is often based upon the credulity and goodness of others. 4. Always act rightly, and do not care what other people may think of you. 5. Knock again; someone must be in, because there is a light in the rooms upstairs. 6. It seems that some people rejoice at other people's misfortunes. 7. If you do not tell me everything exactly, we shall do nothing. 8. Always tell the truth if you wish others to esteem you. 9. Those who possess nothing are always the most generous. 10. Nothing is useless; everything has its reason for existing.

KEY TO EXERCISE XXXIX.

1. In that country it snows very seldom, but it always rains. 2. It rains hard; we must take a carriage. 3. It will be necessary to leave early if we wish to arrive in time. 4. It has hailed and rained all night. 5. It does not thunder any more, but it lightens still. 6. It is better not to go out to-day; it is very foggy. 7. Let us go; it is not worth while to stay here to speak of useless things. 8. Your friend seems very happy; he must have done good business on the exchange. 9. It seems that he is happy, but really it is not so. 10. Russia has imported a great quantity of corn this year. 11. It is of consequence to decide at once, because there is no time to lose. 12. You have already spoken enough; it is my turn now. 13. One is sorry to see young people so idle. 14. One must enjoy oneself a little in this life; one lives only once.

Continued

FRENCH

Continued from page 4508

By Louis A. Barbé, B.A.

IRREGULAR VERBS

Second Conjugation

1. **Acquérir,** to acquire, *acquérant, acquis.*

Ind. Pres.—j'acquiers, tu acquiers, il acquiert, nous acquérons, vous acquérez, ils acquièrent.

Imperf.—j'acquérais.

Past Definite—j'acquis.

Future.—j'acquerrai.

Cond. Pres.—j'acquerrais.

Subj. Pres.—que j'acquière, que tu acquières, qu'il acquière, que nous acquérions, que vous acquériez, qu'ils acquièrent.

Imperf.—que j'acquisse.

Conquérir, to conquer, *reconquérir*, to reconquer, *s'enquérir de*, to inquire about, and *requérir*, to request, to call upon, are conjugated in the same way.

In the Future and the Conditional, each "*r*" must be pronounced separately, though the break in the trill must be very slight. This pronunciation is necessary to distinguish these tenses from the Present and Imperfect Indicative.

2. **Courir,** to run, *courant, couru.*

Ind. Pres.—je cours, tu cours, il court, nous courons, vous courez, ils courent.

Imperf.—je courais.

Past Def.—je courus.

Future.—je courrai.

Cond. Pres.—*je courrais.*

Subj. Pres.—*que je coure, que tu coures, qu'il coure, que nous courions, que vous couriez, qu'ils courent.*

Imperf.—*que je courusse.*

The other verbs conjugated like this are: *accourir*, to rush up, hasten; *concourir*, to concur, to compete; *discourir*, to discourse; *encourir*, to incur; *parcourir*, to run through; *recourir*, to have recourse; and *secourir*, to succour. In all these verbs also, the two "r's" of the Future and of the Conditional are to be pronounced separately.

3. **Cueillir,** to gather, to pluck, *cueillant, cueilli.*

Ind. Pres.—*je cueille, tu cueilles, il cueille, nous cueillons, vous cueillez, ils cueillent.*

Imperf.—*cueillais.*

Past Def.—*je cueillis.*

Future.—*je cueillerai.*

Cond. Pres.—*je cueillerais.*

Subj. Pres.—*que je cueille, que tu cueilles, qu'il cueille, que nous cueillons, que vous cueillez, qu'ils cueillent.*

Imperf.—*que je cueillisse.*

Accueillir, to receive, to welcome; and *recueillir*, to collect, are conjugated in the same way.

4. **Mourir,** to die, *mourant, mort.*

Ind. Pres.—*je meurs, tu meurs, il meurt, nous mourons, vous mourez, ils meurent.*

Imperf.—*je mourais.*

Past Def.—*je mourus.*

Future.—*je mourrai.*

Cond. Pres.—*je mourrais.*

Subj. Pres.—*que je meure, que tu meures, qu'il meure, que nous mourions, que vous mouriez, qu'ils meurent.*

Imperf.—*que je mourusse.*

This verb has a reflexive form, *se mourir*, to be dying. *Mourir* is conjugated with *être* in its compound tenses. Both "r's" of the Future and of the Conditional are to be pronounced distinctly.

5. **Tenir,** to hold, *tenant, tenu.*

Ind. Pres.—*je tiens, tu tiens, il tient, nous tenons, vous tenez, ils tiennent.*

Imperf.—*je tenais.*

Past Def.—*je tins, tu tins, il tint, nous tînmes, vous tîntes, ils tinrent.*

Future.—*je tiendrai.*

Cond. Pres.—*je tiendrais.*

Subj. Pres.—*que je tienne, que tu tiennes, qu'il tienne, que nous tenions, que vous teniez, qu'ils tiennent.*

Imperf.—*que je tinsse.*

Idiomatic Uses of Tenir. (*a*). *Tenir de* followed by a personal noun means "to take after," "to resemble."

Cet enfant tient de sa mère, That child takes after his mother.

(*b*). *Tenir à* followed by a noun or preceded by "*y*" means "to value," "to set store by."

Ne perdez pas ce livre, j'y tiens, Do not lose that book, I value it.

When followed by an infinitive, it means, "to be anxious to."

Je tiens à lui dire ce que j'en pense, I am anxious to tell him what I think about it.

Tenir à ce que followed by a personal tense has the same meaning. It is followed by the Subjunctive:

Je tiens à ce qu'il nous dise ce qu'il en pense, I am anxious he should tell us what he thinks about it.

Tenir à used impersonally means, "to depend on": *Il ne tient qu'à vous de réussir*, It only depends on you to succeed—*i.e.*, It will be your fault if you do not succeed.

The derivatives of *tenir* are: *s'abstenir*, to abstain; *appartenir*, to belong; *contenir*, to contain; *détenir*, to detain; *entretenir*, to keep up; *maintenir*, to maintain; *obtenir*, to obtain; *retenir*, to retain, to remember; *soutenir*, to sustain; *se tenir*, to stand, to hold oneself.

6. **Venir,** to come, *venant, venu.*

Ind. Pres.—*je viens, tu viens, il vient, nous venons, vous venez, ils viennent.*

Imperf.—*je venais.*

Past Def.—*je vins, tu vins, il vint, nous vînmes, vous vîntes, ils vinrent.*

Future.—*je viendrai.*

Cond. Pres.—*je viendrais.*

Subj. Pres.—*que je vienne, que tu viennes, qu'il vienne, que nous venions, que vous veniez, qu'ils viennent.*

Imperf.—*que je vinsse.*

Venir is conjugated with *être* in its compound tenses.

Idiomatic Uses of Venir. (*a*). *Venir de* followed by an infinitive means, "to have just": *Je viens de le voir*, I have just seen him; *Il venait de sortir*, He had just gone out.

(*b*). *Venir à* followed by an infinitive means "to chance to," "to happen to": *Pendant que le marquis de Carabas se baignait, le roi vint à passer*, Whilst the Marquess of Carabas was bathing, the King happened to pass.

(*c*). There is also a reflexive form, *s'en venir*, "to come along, to come away":

Nous nous en vînmes ensemble, We came away together.

The derivatives conjugated like *venir* are:

circonvenir, to circumvent
contrevenir, to infringe
convenir, to agree, to suit
devenir, to become
disconvenir, to disagree
intervenir, to intervene
parvenir, to reach, to succeed
prévenir, to warn
provenir, to proceed
redevenir, to become again
revenir, to come back
subvenir, to provide
survenir, to come by chance
se souvenir de, to remember
se ressouvenir de, to recollect again

EXERCISE XXXIII.

1. Little Red Riding Hood (*Le Petit Chaperon Rouge*) set out to go to her grandmother's, who lived in another village.

2. The wolf that she met asked her where she was going.

3. The little girl said to him: "I am going to see my grandmother and to take (*porter*) her a cake (*une galette*) with a little pot (*le pot*) of butter (*beurre*) which my mother is sending her."

4. The wolf began to run with (*de*) all his might (*la force*) by the road which was the shortest, and the little girl went off by the longest road, loitering (*s'amuser*) to gather nuts (*la noisette*) and to run after butterflies (*le papillon*).

5. Puss in Boots (*le Chat Botté*) said to the Ogre (*Ogre*): "I have been assured that you had the power (*le pouvoir*) to change (*changer*) yourself into (*en*) a rat, and a mouse (*la souris*); I confess (*avouer*) to you that I consider (hold) that quite impossible."—"Impossible," replied (*reprendre*) the Ogre, "you are going to see."

6. "It will depend only on you, Marquess" (*Monsieur le marquis*), said the King "to be (that you be, subj. pres. preceded by *ne*) my son-in-law" (*gendre*).

7. The Cat became (a) great lord, and no longer ran after mice, except (*que*) to amuse himself (*se divertir*).

8. The fairy (*la fée*) said to Cinderella (*Cendrillon*): "Go (thou) into the garden; you will find there six lizards (*le lézard*) behind (*derrière*) the watering-can (*arrosoir*, m.); bring them to me."

9. "I recommend you (*recommander*) above all (*surtout*) not to pass midnight; if you remain (*demeurer*) at the ball a moment longer (more) your coach (*le carrosse*) will become (a) pumpkin (*la citrouille*) again, your horses mice, your footmen (*laquais*) lizards, and your old clothes (*les habits*, m.) will resume (*reprendre*) their first form" (*la forme*).

10. The old fairy said that the princess would pierce (*se percer*) her hand with (*de*) a spindle (*le fuseau*) and that she would die of it.

11. The princess will pierce her hand, but she will not die of it; instead of dying of it, she will fall into a deep sleep which will last a hundred years, at the end (*le bout*) of which the son of a king will come and (to) awaken (*réveiller*) her.

12. Little Hop o' my Thumb (*le Petit Poucet*) went to bed again (*se recoucher*) and did not sleep for the (*du*) rest of the night; he got up early (*de bon matin*) and went to the bank (*le bord*) of a stream (*le ruisseau*), where he filled (*emplir*) his pockets (*la poche*) with (*de*) little white pebbles, and then (*ensuite*) came back to the house.

Key to Exercise XXXII.

1. Quand les anciens assiégeaient une ville, ils battaient les murs à coups de bélier.

2. On n'est jamais battu sans être frappé; mais on peut être frappé sans être battu.

3. Le muletier qui nous servait de guide, battait ses mules d'une façon épouvantable.

4. Nous n'avons rien conclu, mais ce n'est pas ma faute.

5. C'est un auteur dont les ouvrages ont été traduits dans toutes les langues.

6. Selon un écrivain distingué, si vous traduisez toujours, on ne vous traduira jamais; et cependant, un autre écrivain tout aussi distingué a dit que si vous voulez qu'on vous traduise un jour, vous devez commencer par traduire vous-même.

7. Je ne l'ai vu qu'une fois, mais je le connaîtrais entre mille.

8. Cette jeune fille coud, chante, lit; c'est tout ce qu'il lui faut pour être heureuse.

9. Qui est-ce qui disait que, partout où la peau du lion ne suffisait pas, il fallait y coudre la peau du renard, c'est à dire joindre la ruse à la force?

10. Il y a des gens qui ne comptent le reste des hommes pour rien, et ne croient être nés que pour eux-mêmes.

11. Un honnête homme qui dit oui et non mérite d'être cru; son caractère jure pour lui.

12. Tout auteur qu'on est obligé de lire deux fois pour l'entendre écrit mal.

13. Ce qui est écrit est écrit veut dire qu'on ne peut rien changer à ce qui est écrit.

14. Le bon pasteur a dit: "Je connais mes brebis et mes brebis me connaissent."

15. Il est admis par tous les peuples civilisés que la personne d'un ambassadeur est inviolable et sacrée.

16. Vous nous peignez si bien les charmes de la vie champêtre que vous nous donnez l'envie d'aller habiter au village.

17. Les Gaulois se transmettaient les nouvelles en allumant des feux sur les hauteurs.

18. Les jours croissent du vingt et un décembre au vingt et un juin; ils décroissent du vingt et un juin au vingt et un décembre.

19. Les hommes sont comme les fleurs qui paraissent et disparaissent avec une incroyable rapidité.

20. Le onze novembre mil cinq cent soixante-douze, une étoile nouvelle apparut tout à coup dans le ciel, où elle brilla du plus vif éclat; elle disparut au mois de mai mil cinq cent soixante-quatorze après avoir duré seize mois.

21. On lit dans la Genèse que les anciens patriarches vivaient fort longtemps, et qu'Abraham vécut cent soixante-quinze ans.

22. Nous écrivons de gauche à droite; les Juifs écrivent de droite à gauche; les Arabes écrivent également de droite à gauche.

23. Les Français vainquirent les Autrichiens à Jemmapes et à Marengo; ils furent vaincus par les Anglais à Waterloo.

24. Les anciens moulaient le blé avec de petites meules mues à bras d'hommes.

25. Les actions injustes nuisent toujours à leurs auteurs.

26. Cléopâtre prit une grosse perle, qu'elle jeta dans une tasse, et, quand elle l'eut vue dissoute, elle l'avala.

27. Vous riez, et avec raison, des sottises des hommes, dont je ferais bien de rire aussi, et dont je rirais comme vous, si je digérais et si je dormais mieux.

28. Quelle passion que l'envie! Elle suit l'homme de mérite jusqu'au bord de sa tombe.

Continued

SPANISH Continued from page 4511 By Amalia de Alberti & H. S. Duncan

UNCLASSIFIABLE IRREGULAR VERBS—continued

There are still a few irregular verbs which cannot be classified; these are given in the order of their conjugation:

First Conjugation

Andar, to walk, to go about.

This verb is perfectly regular except in the following tenses:

Past Def.—anduve, anduviste, anduvo, anduvimos, anduvisteis, anduvieron.

Subj. Imperf.—anduviera, anduvieras, anduvieramos, anduvierais, anduvieran, or *anduviese,* etc.

Subj. Fut.—anduviere, anduvieres, anduviere, anduvieremos, anduviereis, anduvieren.

Dar, to give; *dando,* giving; *dado,* given.

Ind. Pres.—doy, das, dá, damos, dáis, dan.

Imperf.—daba, dabas, daba, dábamos, dábais, daban.

Past Def.—dí, diste, dió, dimos, disteis, dieron.

Imperat.—da, dé, demos, dad, den.

Subj. Pres.—dé, des, de, demos, deis, den.

Subj. Imperf.—diera, dieras, diera, dieramos, dierais, dieran or *diese, dieses,* etc.

Subj. Fut.—diere, dieres, diere, dieremos, diéreis, diren.

The future and conditional of the indicative are regular.

Second Conjugation

Caber, to be contained in, to hold, to fit into.

Ind. Pres.—quepo, cabes, cabe, cabemos, cabeis, caben.

Imperf.—cabia, cabias, cabia, cabiamos, cabiais, cabian.

Past Def.—cupe, cupiste, cupo, cupimos, cupisteis, cupieron.

Fut.—cabré, cabrás, cabrá, cabrémos, cabréis, cabrán.

Condit.—cabria, cabrias, cabria, cabríamos, cabríais, cabrían.

Imperat.—cabe, quepa, quepamos, cabed, quepan.

Subj. Pres.—quepa, quepas, quepa, quepamos, quepais, quepan.

Subj. Imperf. cupiera, cupieras, cupiera, cupiéramos, cupiérais, cupieran, or *cupiese,* etc.

The verb *Caber* is also used impersonally. Examples: *No cabe en lo posible,* It is impossible; *Si cabe,* If possible; *No cabe duda,* There is no room for doubt.

Caer, to fall.

Ind. Pres.—caigo, caes, cae, caemos, caeis, caen.

Subj Pres.—caiga, caigas, caiga, caigamos, caigais, caigan.

Imperat.—cae, caiga, caigamos, caed, caigan.

All the other tenses of this verb are regular, but subject to the usual change of *i* to *y* when the diphthongs *ie* and *io* of the verbal termination meet the radical vowel.

Past Def.—caí, caiste, cayó, caímos, caísteis, cayeron.

Hacer, to do; *haciendo,* doing; *hecho,* done.

Ind. Pres.—hago, haces, hace, hacemos, haceis, hacen.

Past Def.—hice, hiciste, hizo, hicimos, hicisteis, hicieron.

Fut.—haría, harás, hará, harémos, hareis, harán.

Cond.—haré, harias, haria, hariamos, hariais, harian.

Imperat.—haz, haga, hagamos, haced, hagan.

Subj. Pres.—haga, hagas, haga, hagamos, hagais, hagan.

Subj. Imperf.—hiciera, hicieras, hiciera, hicieramos, hicierais, hicieran, or *hiciese,* etc.

Subj. Fut.—hiciere, hicieres, hiciere, hiciéremos, hiciéreis, hiciéren.

The imperfect of the indicative is regular.

Poder, to be able; *pudiendo,* being able; *podido,* been able.

Ind. Pres.—puedo, puedes, puede, podemos, podeis, pueden.

Past Def.—pude, pudiste, pudo, pudimos, pudisteis, pudieron.

Subj. Pres.—pueda, puedas, pueda, podámos, podais, puedan.

Subj. Imperf.—pudiera, pudieras, pudiéra, pudieramos, pudiérais, pudieran, or *pudiése,* etc.

Subj. Fut.—pudiére, pudiéres, pudiére, pudiéremos, pudiereis, pudiéren.

There is no imperative; the imperfect of the indicative is regular, also the future and conditional, excepting for the elision of the *e* in the termination: *Fut., podré,* etc. *Condit., podria,* etc. The English equivalent of *poder* is can—I can, thou canst, etc.

Poner, to put, *poniendo, puesto.*

Ind. Pres.—pongo, pones, pone, ponemos, poneis, ponen.

Past Def.—puse, pusiste, puso, pusimos, pusisteis, pusiéron.

Imperat.—pon, ponga, pongámos, poned, pongan.

Subj. Pres.—ponga, pongas, ponga, pongámos, pongáis, pongan.

The imperfect of the indicative is regular, also the future and conditional, save for the elision of *e* as in *poder.* The remaining tenses of the subjunctive have *pus* for stem throughout with regular terminations: *pusiéra,* etc.; *pusiese,* etc.; *pusiere,* etc.

Querer, to will, to wish; *queriendo, querido.*

Ind. Pres.—quiero, quiéres, quiere, querémos, quereis, quieren.

Past Def.—quise, quisiste, quiso, quisimos, quisisteis, quisieron.

Imperat.—quiere, quiera, querámos, quered, quiéran.

Subj. Pres.—quiéra, quieras, quiera, querámos, querais, quiéran.

The imperfect of the indicative is regular; the future and conditional have the regular terminations with the stem *querr, querré,* etc. The remaining tenses of the subjunctive have

regular terminations with the stem *quisi*, *quisierais*, etc.

Querer also signifies to love, to like.

Saber, to know ; *sabiendo, sabido.*

Ind. Pres.—sé, sabes, etc. (regular).

Past Def.—sepa, sepas, sepa, sepámos, sepáis, sepan.

Imperat.—sabe, sepa, sepámos, sábed, sepan.

Subj. Pres.—sepa, sepas, sepa, sepámos, sepáis, sepan.

The imperfect of the indicative is regular ; the future and conditional are regular, save for elision of *e*, *sabré*, etc.

The subjunctive, imperfect and future have the regular terminations with the stem *sup*, *supiera*, etc., *supiése*, etc., *supiére*.

Traer, to bring ; *trayendo, traido.*

Ind. Pres.—traigo, traes, trae, traemos, traeis, traen.

Past Def.—traje, trajiste, trajo, trajímos, trajisteis, trajeron.

Imperat.—trae, traiga, traigamos, traed, traigan.

Subj. Pres.—traiga, traigas, traiga, traigamos, traigais, traigan.

The imperfect and future of the indicative and the conditional are regular.

In the subjunctive, imperfect and future, the stem is *traj*, and the *i* of the verbal termination is dropped: *trajera*, etc.; *trajese*, etc.; *trajere*, etc.

Valer, to be worth ; *valiendo, valido.*

Ind. Pres.—valgo, vales, vale, valémos, valeis, valen.

Imperat.—vale, valga, valgámos, valed, valgan.

Subj. Pres.—valga, valgas, valga, valgámos, valgais, valgan.

The rest of this verb is regular save for the elision of *e* in the future of the indicative and in the conditional: *valdré*, etc. ; *valdria*, etc.

Ver, to see ; *viendo, visto.*

Ind. Pres.—veo, ves, ve, vemos, veis, ven.

Imperat.—ve, vea, veamos, ved, vean.

Subj. Pres.—vea, veas, vea, veamos, veais, vean.

• All the other tenses of this verb are regular.

Vocabulary—Vocabulario

The table	La mesa	Humility	Humildad (f.)
The facade	La fachada	To humble	Humilla
Ostentation	Fachenda (f.	Idolatry	Idolatria (f.)
The factory, the manufactory	La fabrica	The idol	El Idolo
		The church	La iglésia
		The ignorance	La ignorancia
The sash	La faja	An ignorant (person)	Un ignorante
The defect	La falta		
The fatigue	La fatiga	The magnet	El iman
The favourite	El favorito	Impartiality	Imparcialidad (f.)
The freemason	Elfrancmason		
A reward	Un galardon, una recompensa	An impostor	Un impostor
		Imprudence	Imprudencia (f.)
A gallery	Una galeria	Impulse	Impulso (m.)
The cattle farm	La ganaderia	The inauguration	La inauguracion
The cattle-breeder	El ganadero	Animals	Los animales
		A rabbit	Un conejo
Cattle	Ganado (m.)	A hare	Una liebre
A sparrow-hawk	Un gairlan	A wolf	Un lobo
		A vixen	Una zórra
A hammock	Una hamaca	A wild boar	Un jabalí
A rag	Un harapo	An eagle	Un águila
An exploit	Una hazaña	A lark	Una alondra
To stink	Hedér	A quail	Una codorniz
The thread	El hilo	A duck	Un pato
The	El algodon	An owl	Un buho
A	Una hoguera	A sparrow	Un gorrion
An ant	Una hormiga	A magpie	Una hurraca
A merrymaking	Una huelga	A dove	Una tortola

EXERCISE XVII. (1)

Translate the following into Spanish :

1. We went from one town to another. I walk a good deal without being tired, but he cannot walk.

2. I gave alms to a poor man ; it pleases me to give to the really needy.

3. I sit in the armchair ; those (persons) sit on the sofa, and the child lies in the cradle.

4. You can take this manuscript, that is, if you can read it. I cannot decipher it.

5. Put the bread on the table, and afterwards I will put it (in) on the sideboard while they lay the table.

6. I wish them to listen to me, and they will not hear me.

7. My friends know the history of England by heart ; I know that of Spain very well, and with time they will know it also.

8. Bring back good luck with you, and when brought, let us hope it will remain.

9. This picture is not worth much, but when cleaned it will be worth more, and I should not be surprised if it were then worth a great deal.

10. I see that your friendship is given to another ; and, seeing it, mine decreases.

11. The fables of Lafontaine are not so well known as those of Æsop.

12. That man's ostentation is ridiculous.

EXERCISE XVII. (2)

Translate the following into English :

1. La fabrica de tabacos de Sevilla es una de las curiosidades de ese pueblo.

2. La gente del pueblo en Andalucia usan fajas de colores brillantes ; el efecto es muy pintoresco.

3. Se usa la palabra *fatiga* ademas del sentido cansancio como una exclamacion que quiere decir, que *fastidio*, que *apuro*.

4. En tiempo de la caballeria andante recibian los caballeros de manos de sus damas un galardon que conservaban y defendian con su vida.

5. La Galería Nacional en Londres contiene muy buenos cuadros.

6. Los toros que vienen á los pueblos para las corridas son siempre llamados *el ganado*.

7. Hay mendigos, que, vestidos de harapos, conservan aún alguna dignidad.

8. Las hazañas del Cid son conocidas por todo el mundo civilizado.

9. Se hacen muy bonitas telas de algodon ; las de Manchester son las mejores.

10. En las huelgas baila la gente del campo alrededor de las hogueras.

11. La humildad es una virtud, pero el humillar al humilde es el acto de una persona despótica y orgullosa.

12. La ignorancia es atrevida. Nadie dá una opinion mas decidida y perentoria que el ignorante.

KEY TO EXERCISE XVI. (1)

1. Sirviendo á la patria se ganan honores.

2. Seguir el mal ejemplo es malo, sigamos siempre el bueno.

3. Al ceñirse la espada gritó " Viva el Rey."

4. No compitamos con esa casa : sus precios son ridiculamente baratos.

5. No compres esa tela : se destiñe y mancha las manos.

6. Gustosamente despedimos á un huesped desagradable y fastidioso.

7. Es dificil elegir á un compañero de viaje, pero una vez elegido hay que avenirse con él hasta el fin de la jornada.

8. Hay que reflexionar antes de investir su patrimonio, pues despues de investido se corre riesgo de no poder retirarlo.

9. Midamos el paño antes de cortar la capa, y cortemoslo segun la medida.

10. Persiguieron al enemigo hasta que no pudieron proseguir más lejos.

11. Reñir con sus amigos es cosa de necios.

12. Contribuyamos con buenas obras al bien del prójimo, pero que la contribucion sea sensata.

KEY TO EXERCISE XVI. (2)

1. She is so old and ugly that she looks like a witch.
2. He hurt that child; he is a brute!
3. That man is a brewer; he made his fortune selling beer.
4. He showed me a very ancient dagger: the workmanship is very fine.
5. The strawberry beds in my garden extend for half a league.
6. There are very fine fruit trees in the orchard.
7. The figs, pears, and apples are very delicious.
8. Heather grows on mountains.
9. The lemons and oranges which grow on our lemon and orange trees are noted for being good. Our strawberry beds also yield very large strawberries.
10. The flower of the pomegranate-tree is as pretty as its fruit.
11. It is the fashion to make rush furniture; it is pretty, but not lasting.
12. The box of the Alcazar of Seville is celebrated for its age and beauty.
13. In Spain they make a preserve of almonds and nuts called *turron*, which is very good.
14. Olive trees are sad and melancholy-looking: their foliage is nearly black.

PROSE EXTRACT XIV.

From "La Barraca" (The Hut), by Vicente Blasco Ibañez.

The wide plain was rousing itself in the blue gleam of dawn, which rose like a broad band of light above the sea.

Desperezábase la inmensa vega bajo el resplandor azulado del amanecer, ancha faja de luz que asomaba por la parte del mar.

The last nightingales, weary of enlivening with their songs the spring-like mildness of the autumn night, sent forth their final trills, as if the light of morning had pierced them with its steely rays.

Los últimos ruiseñores, cansados de animar con sus trinos aquella noche de otoño que por lo tibio de su ambiénte parécia de primavera, lanzaban el gorjeo final como si les hiriera la luz del alba con sus reflejos de acero.

Bands of sparrows arose from the straw-thatched roofs of the huts, like a troop of street arabs in full flight, and the tree-tops trembled with the first gambols of these urchins of the air, which was all filled with the noisy rustling of their feather tunics.

De las techumbres de paja de las barracas salían las bandadas de gorriones como tropel de pilluelos perseguidos, y las copas de los arboles estremecíanse con los primeros jugueteos de aquellos granujas del espacio que todo lo alborotaban con el roce de su blusa de plumas.

The noises of the night died slowly away—the lapping of watercourses, the whispering of rushes, the barking of vigilant mastiffs.

Apagábanse lentamente los rumores que poblaban la noche—el barboteo de las acequias, el murmullo de los cañaverales, los ladridos de los mastines vigilantes.

The plain was waking: its yawning grew louder and louder every moment. The crowing of cocks spread from hut to hut; the belfries of the little villages sent forth their noisy peals for the first Mass, ringing afar from the blue turrets of Valencia, which showed misty in the distance. A discordant animal concert arose from the farmyards—the neighing of horses, the lowing of meek kine, the cackle of hens, the bleating of sheep, and the grunting of swine; the noisy awakening of beasts which, feeling the fresh caress of morning laden with the acrid smell of vegetation, long to roam the fields.

Despertaba la huerta, y sus bostezos eran cada vez más ruidosos. Rodaba el canto del gallo de barraca en barraca; los campanarios de los pueblecitos devolvían con rindosas badajadas el toque de misa primera que sonaba á lo lejos en las torres de Valencia, azules, esfumadas por la distancia, y de los corrales salió un discordante concierto animal, relinchos de caballos, mugidos de mansas vacas, cloquear de gallinas, balidos de corderos, ronquidos de cerdos, el despertar ruidoso de las bestias que al sentir la fresca caricia del amanecer cargada de aire, perfume de vegetación, deseaban correr por los campos.

All space was gradually soaked with light; the shadows vanished as though swallowed by the open furrows and masses of foliage; and from the vague twilight of the dawn emerged the brilliant and humid outlines of rows of mulberry and fruit trees, the swaying lines of rushes, the great squares of growing vegetables like enormous green handkerchiefs, and of carefully ploughed red earth.

El espacio se empapaba de luz, disolvíanse las sombras como tragadas por los abiertos surcos y las masas de follaje, y en la indecisa neblina del amanecer iban fijándo sus contornos húmedos y brillantes las filas de moreras y frutales, las ondulantes líneas de cañas, los grandes cuadros de hortalizas semejantes á enormes pañuelos verdes y la tierra roja cuidadosamente labrada.

Upon the roads appeared files of moving black specks, like a rosary of ants making towards the city. From every corner of the plain arose the creaking of wheels, and a sound of lazy singing, interrupted by a shout of encouragement to the beasts; and every now and then, like the sonorous trumpet-call of morning, the air was rent by the furious braying of the four-footed pariah, as if in protest against the heavy labour which fell upon him almost at break of day.

En los caminos marcábanse filas de puntos negros y movibles como rosarios de hormigas que marchaban hacía la ciudad. Por todos los extremos de la vega sonaban chirridos de ruedas, canciones perezosas interrumpidas por el grito arreando las bestias, y de vez en cuando como sonoro trompetazo del amanecer, rasgaba el espacio un furioso rebuzno del cuadrúpedo pária, como protesta del pesado trabajo que caía sobre él apenas nacido el dia.

In the water-courses the smooth sheet of reddish crystal was troubled by loud plungings, which silenced the frogs, and in a noisy flapping of wings the swans advanced like galleys of ivory, their long serpent-necks moving like fantastic prows.

En las acequias conmoviase la tersa lámina de cristal rojizo con sonoros chapuzones, que hacían callar á las ranas, y ruidoso batir de alas y como galeras de marfil avanzaban los cisnes moviendo cual fantasticas proas sus cuellos de serpiente.

Life, which inundated the plain, together with the light, penetrated into the interior of the huts and farmhouses.

La vida que con la luz inundaba la vega, penetraba en el interior de las barracas y alquerías.

Vicente Blasco Ibañez, who was born in 1867, is considered one of the foremost living novelists in Spain. "The Hut" is a tragic story of village life, told with grim power and great literary beauty of style.

Vicente Blasco Ibañez, nació en 1867, es considerado en España como uno de los primeros novelistas de nuestro tiempo. "La Barraca" es una historia trágica de la vida de aldea, dicha con una fuerza sombria, y un hermoso estilo literario.

Continued

ESPERANTO

Continued from page 4512

By Harald Clegg

PREPOSITIONS

There are thirty-four words in Esperanto which are essentially prepositions, and to each of which a fixed meaning and power are given. They govern the nominative case and not the objective, as in English. Care must be taken in translating English prepositions to see that the exact sense required is given to the phrase. When we say in English, "I saw a man with a telescope," the meaning of "with a telescope" is ambiguous, and "Lessons in Esperanto" may mean that instruction on a subject is given in that language, or that Esperanto is the subject about which instruction is given; so that in all cases the preposition selected must be that which gives a logical meaning to the idea to be expressed. When, however, it happens that none of these will accurately convey the sense desired, there lies in reserve the preposition *je*, with no definite signification; but as proficiency in Esperanto is acquired, the necessity for using that word decreases. It should only be used as a last resort. An alternative course is to omit the preposition and employ the objective case, but this should only be done when the clearness of the meaning is not affected. Nearly all prepositions may be used as prefixes to words. We thus get:

ĉeesti, to be at, to be present at
aliri, to go to
priparoli, to speak about

[See Vocabulary.]

It is important to remember that, as in English, prepositions do not end phrases. "The man John spoke to" must be translated, "*La viro al kiu Johano parolis*" (The man to whom John spoke).

The following are the most commonly used prepositions:

- ***al***, to, towards
- ***ĉe***, at, at the place of, at the time of, with
- ***da***,* of (used after words indicating weight, measure, and quantity)
- ***de***, of, from, by (denoting origin or starting point)
- ***el***,† out of, from among, extraction
- ***en***, in, into
- ***jen***, behold. *Jen estas*, here is, here are
- ***kun***, with, in company of (never indicating the instrument).
- ***per***, by, by means of, through, with (marking the instrument)
- ***por***,‡ for, in order to
- ***pri***, concerning, about, relating to, of
- ***pro***, on account of, for the sake of, owing to
- ***sen***, without
- ***sub***, under
- ***sur***, on, upon (actually touching)
- ***tra***, through

* This word is used instead of, and to distinguish it from, *de* in such cases as the following:

A plate of soup, *Telero da supo*, meaning a plateful of soup, and:

A plate for soup (soup plate), which is *Telero de* (or *por*) *supo*.

† Also, to do a thing thoroughly. Ex.: *Ellerni*, learn thoroughly.

‡ The mood of any verb which immediately follows *por* is always infinitive.

THE VERB (Past Tense)

The past tense is formed by the addition of *is* to the root word, and is the same for all persons, singular and plural. Examples:

The father birched the child, *La patro vergis la infanon*. The men accepted the papers, *La viroj akceptis la paperojn*.

VOCABULARY

afer', affair, matter	*hodiaŭ**, to-day
akv', water	*ir'*, go
aŭd', hear	*ĵaŭd'*, Thursday
amas', crowd	*kant'*, sing
arb', tree	*koncert'*, concert
bezon', need, want	*leon'*, lion
blov', blow (*v.*)	*lund'*, Monday
botel', bottle	*mastro*, master
bol', boil (*v.n.*)	*mard'*, Tuesday
bru', noise	*merkred'*, Wednesday
ĉambr', room, chamber	*muzik'*, music
ĉeriz', cherry	*nokt'*, night
danc', dance	*parol'*, speak
demand', ask, question	*pastr'*, priest
dimanĉ', Sunday	*pet'*, ask for, beg
far', make, do	*popol'*, people
fil', son	*rest'*, remain, stay
frat', brother	*strat'*, street
funt', pound	*sabat'*, Saturday
ĝarden', garden	*semajn'*, week
general', general (army)	*sinjor'*, sir, Mr., gentleman
ĝu', enjoy	*soldat'*, soldier
glas', glass (wine, etc.)	*teatr'*, theatre
*hieraŭ**, yesterday	*tag'*, day
	vend', sell
	vendred', Friday
	vent', wind(s)
	vin', wine

EXERCISE 2.

The soldiers went through the streets. Sunday, Monday, Tuesday, Wednesday, Thursday, Friday and Saturday are days of the week. In the night the son heard a noise. The water and the soup are boiling. The father spoke to the soldier about the matter. The children danced in the room, and the birds sang on the tree. The general had a bottle of wine, and asked for a glass of water. The cherries remained on the tree. On Friday and Saturday (the) father and (the) brother went to the theatre to hear the concert. Yesterday the priest bought a pound of cherries, and to-day the son of the general sold a bottle of wine to the cousin. Here is a pipe and the gazette. Here are some cherries and a water-glass. The lion has teeth. The water remained on the table in the room. Here is a crowd of men in (on) the street. The gentleman and the master heard the noise and spoke to the priest about the affair. The son saw the brother at the theatre. At the concert the gentleman sang and the people enjoyed the music. The bird went out through the window. In his (the) hand the soldier had a stick.

PRONOUNS

The PERSONAL PRONOUNS are:

Singular:

I	*mi*	she	*ŝi*
thou	*ci*	he	*li*
you	*vi*	it	*ĝi*

Plural:

we	*ni*	you	*vi*
They	*ili*		

There are also *si*, REFLEXIVE PRONOUN (used for all numbers and both sexes, in the third person only, and never as subject of a sentence), and *oni*, an indefinite pronoun, which represents it, they, people, one. It is the French *on*. All the above pronouns (with the possible exception of *oni*), like the noun when the direct object of a verb, take the accusative *n*, but naturally they cannot take the plural *j*. *Ci* is very rarely used, only being employed in translation, where fidelity to the original requires it. As will be seen above, *vi* is used in the second person both singular and plural. *Ĝi* is used in speaking of inanimate objects, or to indicate animals, and even children, when the sex is not particularly

to be distinguished. *Si*, the reflexive pronoun, is something new to the English learner, and its functions must be carefully noted. It stands for the English words self and selves, as in himself, herself, itself, themselves, and is employed when the idea expressed by the verb in the sentence refers to the subject. Examples:

He spoke to himself, *Li parolis al si* (not *li*). The father and the brother bought wine for themselves, *La patro kaj la frato aĉetis vinon por si*. She washes herself, *Ŝi lavas sin* (not *ŝin*).

Emphasis may be given to the meaning by adding *mem*, and this word may be used after any of the personal pronouns. Examples:

I myself paid the man, *Mi mem pagis la viron*. They thanked themselves, *Ili dankis sin mem*.

The indefinite pronoun *oni* (third person) is used in a general sense when nobody in particular is spoken of, as:

It is said, They say, *Oni diras*.
I was told, *Oni diris al mi*.

AFFIXES

Besides the prepositions beforementioned, which are used as prefixes to form new words, there is an elaborate system of affixes, consisting of thirty-two words, which are prefixed or added to the regular roots. It is of the first importance for learners to be fully acquainted with the meaning and value of these particles, as they form a stock of separate words which will not be given in the attached vocabularies. By their aid it is possible to form an indefinite number of cognate words which express every possible shade of thought, without obliging the student to learn distinct words for each object or idea. The vocabularies will be searched in vain for such words as small, bad, woman, chicken, forest, as these are constructed by means of affixes from the words large, good, man, cock, tree. From the single word *san'*, meaning health, fifty perfect words can be formed, thus demonstrating the possibility of acquiring words without unnecessary labour.

Prefixes. *Mal* denotes the direct opposite of any idea (not simply its negative). Example: *Admiri*, admire; *maladmiri*, detest. *Bono*, good; *malbono*, evil.

Bo denotes a relation by marriage. Example: *Patro*, father; *bopatro*, father-in-law. *Frato*, brother; *bofrato*, brother-in-law.

Dis denotes separation. Example: *Ĵeti*, to throw; *disĵeti*, to scatter. *Ŝiri*, to tear; *disŝiri*, to tear to pieces.

VOCABULARY

adiaŭ, good-bye, adieu
alumet', lucifer
amik', friend
aparten', belong
barb', beard
bier', beer
blek', cry (of animals)
cigar', cigar
cit', cite, mention
ĉes', cease, stop
ĉeval', horse
decid', decide
dev', be obliged (to)
don', give
dub', doubt
entrepren', undertake
esting', extinguish
faj', fire
famili', family
gas', gas
gorĝ', throat
grup', group
har', hair (*sing.*)
hejm', home
help', help
hom', man, human being
horloĝ', clock
hund', dog
jes, yes
kaf', coffee
*kon'** know
kor', heart
loĝ, live, lodge
pov', able to
propon', propose, offer
sem', sow
sci' † know
skatol', box
ŝip', ship
ŝton', stone
te', tea
ven', come
vintr', winter
viv', live
vol', willing to
vort', word
voj', way, road
vund', wound

* *Kon'* means to be personally acquainted with, to understand the nature of, to know of, to know who such a person is, or what such a thing is.

† *Sci'* means to know, to perceive with the mind, never to know a person.

EXERCISE 3.

I want (beg) a glass of beer and a pipe. You must extinguish the fire and the lamp. I heard the neigh of the horse and the bleat of the sheep. He was doubtful about the affair. Father-in-law. Brother-in-law. The ox belongs to her. I can sing and dance. Yes, sir, I have a cigar and matches. He himself was in the garden. She helped me, and I thanked her for the offer. They gave me the book, and I tore it up. He has a friend, and she has an enemy. They want to hinder you. In the winter I live in the house and work. She decided to buy the clock. You mentioned the matter to me. Man has hair(s), throat, hands, and a heart. The fire is burning. You made me an offer, and I accepted it. The matches in the box belong to us. I know you, and you know me. To-day is Wednesday and yesterday was Tuesday. The son-in-law remains in the street with the cousin. In the night the wind blew. The lion wounded itself; it roared and made a noise. Good-bye, friend, I want to thank you for the help.

ADJECTIVES

The adjective is formed by the addition of *a* to the root word, and always agrees in number and case with the noun which it qualifies. Examples:

Nom. sing.: *Forta viro eniris*, A strong man entered;
,, plur.: *Fortaj viroj eniris*, Strong men entered.
Obj. sing.: *Mi vidis fortan viron*, I saw a strong man;
,, plur.: *Mi vidis fortajn virojn*, I saw (some) strong men.

Adjectives used predicatively always agree in number with the noun, but are always in the nominative case. Examples:

La viro estas forta, The man was strong.
La viroj estas fortaj, The men were strong.
Li trovis la teon bona, He found the tea (to be) good.

In the latter example there is a supplemental predication which is shown by the easy intermission of the auxiliary infinitive, and, as before-mentioned, the accusative can never follow any form of the auxiliary verb *esti*.

KEY TO EXERCISE 1.

Onklo, ŝafo (or ŝafoj), la bastono, la fenestroj, skribi, danki, puni, tondi, vidi. La kuzo laboras. La edzo skribas. La ŝafo staras. Onklo punas. La ŝafoj kuras. La edzoj aĉetas gazetojn. Patro admiras la aglon. La infano tondas la paperon. La aglo estas birdo. Onklo havas seĝon, tablon, kaj bastonon. Ŝafoj kaj bovoj estas bestoj. La patro fermas la fenestrojn. La edzo havas ĉapelon kaj la ŝafoj havas vostojn. La aglo vidas la infanojn. La infano dankas la patron. La viro aĉetis tablon kaj seĝojn. La viro akceptas la ĉapelon.

Continued

MODERN COMMERCE

From the Painting by FRANK BRANGWYN, A.R.A., in the Royal Exchange

This picture is a companion picture to "Phœnicians Trading with the Early Britons on the Coast of Cornwall," by Lord Leighton, which is the Frontispiece to Volume I. of the SELF EDUCATOR.

PRODUCTS OF THE FOREST

Temperate and Tropical Timber. Turpentine. Tar. Rubber. Tree Oils. Ground Nuts. Tropical Gums and Resins

Continued from page 4520

By Dr. A. J. HERBERTSON, M.A., and F. D. HERBERTSON, B.A.

IN a limited space it is impossible even to enumerate the commodities of which civilised man makes use. The depths of the sea and the bowels of the earth are ransacked for their treasures. In the plant world, root, stem, sap, bark, leaf, bud, flower, and fruit are all utilised. The very parasites of the tree are sometimes pressed into service. In the animal world there is hardly a creature or an organ for which some use is not found. Meat, blood, intestines, bones, sinews, horns, hoofs, hides, and furs, all have their purpose to serve. If the bounty of Nature is almost inexhaustible, the ingenuity of man is hardly less so.

The Products of the Forest. Two regions of the world are densely forested, the temperate lands, and the tropical regions near the equator. The products of the two are very different.

In the north temperate belt of the Old World forests cover Sweden and Russia and stretch eastwards across Siberia. In the corresponding regions of the New World are the dense forests of Eastern Canada and the Eastern United States. These forests are *coniferous* in the northern and the higher parts, and *deciduous* in the southern and the lower parts.

The chief products of the temperate forests are timber, lumber, turpentine, pitch or tar, and resins and gums.

Timber. Timber is the oldest and most widely distributed building material in the world, as well as the most universal fuel. Its other uses are innumerable, from the great cargo ships of trading nations down to the nicely adjusted handles of an infinite variety of tools. Next to the food-stuffs, timber is, perhaps, the most indispensable of materials.

No natural product has been used more recklessly. Before the introduction of coal, enormous quantities were used, not merely as domestic fuel, but for such purposes as smelting metals. The Weald of Southern England is one of many districts thus deforested. This method of smelting is still practised in forest districts of Russia and Sweden. In regions as far apart as Mexico and Amuria wood is the fuel employed both for railway and steamboat traffic. Still greater is the amount of valuable timber which has been wantonly destroyed in clearing land for cultivation. Forest fires annually destroy vast quantities both in Canada and the United States. The demand for timber is steadily increasing all over the world, while the more accessible forests have been greatly reduced in area. Hence the price is steadily rising. The timber imported into Britain in 1905 was valued at over £27,000,000. [See the section on Forestry in APPLIED BOTANY.]

Timber, being bulky and heavy, can only be cheaply transported by water. Where the forested regions are mountainous, as is often the case, timber can be cheaply floated down stream to the sea. Much timber is sawn by water power, and transported in that form. Much is reduced to wood pulp, of which paper is made.

Lumber. Lumber is sawn timber. The value depends largely on the absence of knots, to avoid which the tree must be prevented from branching as long as possible. [See MATERIALS AND STRUCTURES, page 57.] Pine forests require a century to mature, but a solitary pine only half that time. The Scotch pine, one of the most valuable European timber trees, may live 400 years. Oak forests mature still more slowly.

The timber exported from the Baltic ports is the red wood of the Scotch fir, and the white wood of the spruce fir. Both are used for roofing, flooring, street paving, etc., the latter in the cheaper lines. The Weymouth, or yellow pine—the white pine of the United States—is commercially the most valuable tree of Canada and the Eastern United States. It is very free from resin. The pitch pine, ranging farther south, is heavy resinous, and harder to work. It is extensively used on both sides of the Atlantic. The giant pines of the Pacific seaboard yield timber for masts, etc. The deodar, or Indian cedar, is abundant in the Himalayan forests, and much used in Northern India.

Of deciduous trees, or hardwoods, the strongest and most durable is oak, but it is too expensive unless durability is of prime importance, as in shipbuilding. Unfortunately it rusts iron. Elm, ash, beech, the tough American hickory, and the decorative walnut and maple are the other leading hardwoods.

Turpentine, Pitch and Tar. Many conifers yield a resinous sap. The resin of the New Zealand kauri pine is used for the finest varnishes. Much of it is dug out of the ground on the site of former forests. [See page 1034.]

Turpentine, largely used to dilute paints and varnishes, is distilled from the resinous sap of the pine, particularly from that of the long-leaf or Georgia pine. The forests of Georgia and the Atlantic coastal plain generally yield most of the world's supply of turpentine through the ports of Savannah and Brunswick. The tree is cut near the base, allowing the sap to exude and harden into crude turpentine, from which commercial turpentine is distilled. The residuum forms resin, or rosin, used in making varnish, paper, soap, and sealing wax.

Little turpentine is made in the forest countries of Europe, which supply pitch and tar [see page 1163], obtained from the sap by different processes. In Russia tar is made by allowing wood to smoulder under a covering of turf or earth which excludes the air. Improved methods have been devised by which charcoal can be made at the same time. Creosote, a powerful preservative, is made from tar.

Other Temperate Forest Produce. Oak bark is less used than formerly for tanning; larch bark, hemlock spruce bark (U.S.A., Canada), wattle bark (Australia) and Natal bark being common substitutes. Valonia, the acorn cups of an oak grown in the Levant and exported through Smyrna, are used both for tanning and dyeing. An evergreen oak, found in Spain, Portugal and round the Mediterranean generally, supplies cork.

Tropical Forest Produce. The wealth of the tropical forest, of which only a fraction is yet utilised, far exceeds that of the temperate forest. Many trees yield timber of great strength, while that of others is of exquisite beauty. Teak, with the strength of oak, is largely used for backing the armour plates of ships because it protects iron from rust. It grows in Eastern Asia, Java, and other parts of the East Indies. The British supply is from the carefully regulated forests of Upper Burma. Two gigantic species of Australian eucalyptus supply the hard jarrah and karri wood. The former resists sea water, and is used for piles and the foundations of piers, docks, etc., as well as for railway sleepers, and for street paving.

The forests of the West Indies and Central America supply many ornamental woods, the best known of which is mahogany. Rosewood, another familiar cabinet wood, comes from Brazil. Both are used principally for veneering, a thin layer of the expensive ornamental wood being applied to a cheaper frame. Ebony is the heartwood of a tree found in Ceylon and the East Indies. Boxwood, another Indian tree, which also grows round the Mediterranean, is hard and very fine in grain, and is much used by engravers. The fragrant sandalwood is abundant in the East Indies and New Guinea. Another important group of tropical forest trees are the dyewoods. Logwood, which yields a range of blue and brown dyes, grows in Yucatan and Central America, including British Honduras. Some fine dyewoods are also obtained from the forests of West Africa. Cutch is the juice of an acacia, exported as a dyestuff from Burma and the Straits Settlements. Gambier, a dyestuff obtained from the young leaves of a climbing plant, also comes from the Straits Settlements.

Rubber. Of the tropical trees secreting valuable juices the most important are the rubber-yielding plants, which belong to many different species [see page 808]. The finest rubber comes from South America. Some of its uses were known at the time of the European conquest, but it was of little commercial value till the discovery of *vulcanisation*, which hardens rubber without destroying its elasticity. This is effected by adding sulphur, in quantities varying with the degree of hardness required. The addition of about 50 per cent. of sulphur forms the hard, black substance known as ebonite. Vulcanised rubber is used for innumerable purposes, one of the most important of which is the making of pneumatic tyres.

The finest rubber is the Para rubber, or *Hevea brasiliensis*, from the Amazon Valley, shipped from Para, Manaos, and other ports of the Amazon. Inferior rubbers, from other species, are exported from Ceara and Pernambuco. The rubber exported from Brazil in 1904 exceeded £11,000,000 in value. Many tropical trees of the Old World also yield rubber. In 1904 the Congo Free State exported it to the value of nearly £2,000,000.

The demand for rubber is increasing more rapidly than the supply. Increasing quantities will be obtained from Nigeria, Assam, and Borneo, but less wasteful methods of collection must be adopted, and attention devoted to forming rubber plantations.

Gutta-percha, from the *Dichopsis gutta* and other plants, resembles rubber, and is also capable of vulcanisation. It is obtained from the Malay Peninsula, Sumatra, and Borneo, through Singapore. Its chief use is for coating telegraph wires, especially in submarine cables.

Tree Oils. Many tropical trees yield useful oils. [See page 1032.] The fruit of the oil palm, when crushed, yields palm oil, used in making soap and candles. The coconut palm is a widely-distributed tree which prefers the neighbourhood of the sea. Its seeds are enclosed in a thick husk, and are carried by ocean currents from shore to shore. The oil yielded by the kernel is used in tropical countries for food and many other purposes, and commercially for making stearine candles and soaps, which lather in sea water. The dried kernel forms copra, 100 lb. of which yield about five gallons of oil. Eucalyptus oil is distilled from the leaves of the Australian eucalyptus. Castor oil is obtained from a plant native to India, but cultivated round the Mediterranean and in America. It is used medicinally, but in India also for lighting and lubricating. The finest is "cold-drawn"—that is, obtained by crushing the seeds without heat.

Ground Nuts. Ground nuts are the pods of a leguminous plant, so-called because they bury themselves in the ground to ripen. They are chiefly exported from West Africa, but are also grown in Southern Europe, India, South America, and the Southern United States, where they are called peanuts. The oil can be used as salad oil, and the residuum as a feeding stuff for cattle.

Gums and Resins. The tropical gums and resins include dammar, obtained from a coniferous tree of the East Indies. Copal grows in tropical Africa, especially in Portuguese West Africa, in India, the East and West Indies, and South America. Dragon's blood is a reddish resin from Sumatra. Frankincense, or *olibanum*, is obtained from Southern Arabia and India. Gum arabic is secreted by various acacia trees which flourish chiefly in the Sudan.

Continued

PRACTICAL POULTRY BREEDING

Breeding for Utility rather than Ornament. The Chief Varieties Enumerated. Points of Good Table Birds. Feeding for the Table

Continued from page 4576

By Professor JAMES LONG

THE poultry industry has made great strides during the past ten years. During the previous thirty to forty years Englishmen devoted little attention to the economical side of poultry breeding.

The Fascination of Poultry. The number and beauty of the varieties appealed to thousands of persons, who became fascinated with their plumage, their form, and their colours, and who devoted their efforts to the perfecting of those fancy points which form the basis of the awards of judges. Wonderful skill has, in consequence, been developed and exercised, and it is entirely owing to the art of the breeder that the most perfect varieties of to-day owe their brilliant colours, their mathematical marking, and the symmetry of their combs, ear lobes, and general form.

The principle, however, which is necessarily adopted in the selection of the fittest for reproductive purposes on these lines is entirely opposed to the improvement of economical properties of poultry. Instead of developing the breast and the merry-thought from the point of view of an increase in the quantity and quality of the meat, and instead, too, of increasing the laying powers of the hens by breeding from the best layers, the amateur made a point of selecting his breeding stock wholly and solely on the basis of those qualifications which appeal to the eye, and which are alone calculated to secure prizes in competition. We must, however, in discussing this subject, take things as we find them, and our descriptions of the pure breeds will, therefore, be based upon the existing standards of the most perfect exhibition birds of each breed, a few of which may still be regarded as utilitarian, and if not precisely all they should be, still deserving employment in the practice of breeding for economical purposes.

The Two Main Classes. We may divide the pure breeds of poultry into two classes—those which are useful, whether also ornamental or not, and those which are essentially ornamental, their utility being so comparatively small that they are not worth the attention of those connected with the genuine industry. It will be noticed that the hens of the utility breeds are usually sitters, although in many cases they are layers of an inferior order; also that they are comparatively large in size, whereas the hens of the ornamental breeds are as a rule non-sitters, smaller in size, and, in some cases, layers of a larger number of eggs. Where the non-sitting and the sitting varieties are crossed—and we apply the word *sitter* to the hen which hatches eggs—the females produced are usually sitters, although in many instances they are too sensitive and excitable to be generally entrusted with valuable eggs.

The varieties may be classified as in this table.

THE UTILITY BREEDS OF POULTRY.

	Name.	Sitter or Non-sitter.	Average Weight of Table Cockerel.	Average Weight of Eggs (per doz.)	Average No. of Eggs per Annum.
			lb.	oz.	
	Dorking (4 varieties)	Sitters	8–9	27½	120
	Indian Game	"	7	24	100
	Old English Game (several varieties)	"	4½–5½	24	90
	Modern Game (many varieties)	"	6–7	24	85
	Plymouth Rock (3 var.)	"	7½	27	120
	Orpington (several vars.)	"	6½–7	27	120
	Wyandotte (ditto)	"	6–6½	25	120
French varieties.	La Flèche	Non-sitters	6½	30	120
	Creve Cœur	"	7	31	120
	Houdan	"	5½	26	125
	Bresse	"	5	33	155
	Faverolle	Sitters	6½	27	115
Mediterranean.	Spanish (2 varieties)	Non-sitters	5	30	75
	Minorca (2 varieties)	"	5½	28	130
	Andalusian	"	5½	28	130
	Leghorn (sevl. var.)	"	4½	23-27	140-160
	Ancona	"	4½	24	140
	Hamburgh (6 varieties)	"	4	17–19	170–200
	Red Cap	"	5½	20	170–200
Asiatics.	Brahma (2 varieties)	Sitters	8–9	28½	85
	Langshan	"	8	27	100
	Cochin (5 varieties)	"	8–9	25	80
	Scotch Grey	"	6½	29	120
	Campines (2 varieties)	Non sitters	4½	25	150
	Scotch Dumpies	Sitters	5	No data	100

THE ORNAMENTAL BREEDS OF POULTRY.

Name.	Sitter or Non-Sitter.	Average Weight of Cockerel.	Average Weight of Eggs per Dozen.	Average Number of Eggs per Annum.
		lb.	oz.	
Malay	Sitter	7	21	80
Aseel	"	5	No data	No data
Polish (six varieties)	Non-sitters	5 to 6	23	"
Sultan	"	3	16	
Silkies	Sitters	3	15	50
Frizzle	"	4	Small	No data

Among other ornamental varieties, of which no reliable data exist as regards weight and egg production, are Yokohamas, Rumpless, Naked Necks, and the following varieties of Bantam: Game (in several sub-varieties), Black Rose Game, White Rose Game, Gold and Silver Sebrights, Japanese, Pekins, Brahmas, Booted, Scotch Greys, Nankins, Malays, and Spanish.

The Mediterranean breeds, of which a Leghorn is figured in 1, the Hamburghs [2], Red Caps, Campines, and most of the French breeds lay white eggs. The Asiatics, Orpingtons,

Plymouth Rocks, and Scotch Greys, buff eggs; while the Wyandottes and Game fowls, as a group, lay eggs slightly tinted or creamy. The Mediterranean fowls are all inferior table birds; the Asiatic, Langshans excepted, though larger and carrying more flesh, produce meat of secondrate quality; while the best table fowls include the Dorkings [3], the Game varieties, and the French breeds, which are followed by the Langshans, the Orpingtons, the Scotch Greys, Wyandottes, and Plymouth Rocks. The five last-named may be termed the general purpose varieties.

It should be pointed out that the weights of the cockerels represent young birds of sixteen to twenty weeks fit for the table but not fatted or crammed, and that the average number of eggs indicates, not what is possible, or what has been accomplished in public competition, but what is produced in the ordinary poultry-yard.

Eggs. Whoever keeps poultry for utility purposes will not find the Bantams of any value whatever, and the remark applies equally to a number of the larger varieties, and especially to the six named in the Table of Ornamental Breeds. The best layers will usually be found among the modern productions, such as the Wyandotte [4], the Orpington, and the Langshan. The older varieties, however, may be so stimulated by crossing or by the infusion of alien blood from time to time that their laying powers may be revived, and, indeed, brought to the level of the best producers. As a group the nonsitters are the most frequent layers, but with few exceptions their eggs are small. This fault may be remedied in the ordinary process of selection, under which the birds will be increased in size.

1. BROWN LEGHORN

We may take it, too, as an axiom that a bird of a small breed lays a small egg, and the contrary obtains in the case of the large breeds, although this is not an infallible rule. The breeder, however, for productive purposes should make it an invariable practice to select large hens, inasmuch as the usual result is a larger egg and consequently a larger chicken.

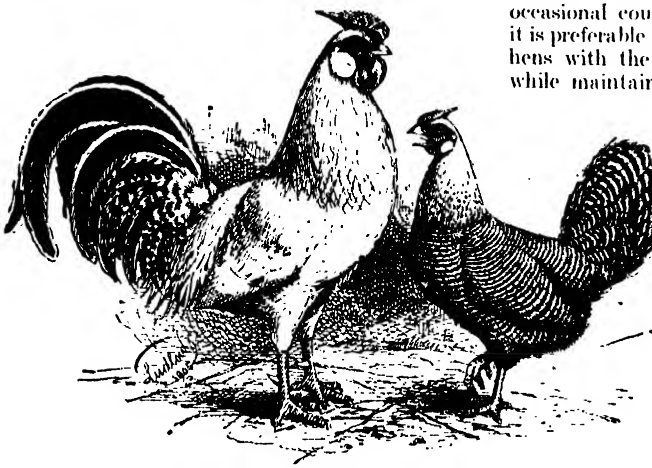
Fowls for the Table. Although many of our remarks apply to poultry of all descriptions—that is to say, to all varieties of birds bred for the purpose of exhibition, as well as to those bred for domestic use or for the market—this course is intended to be chiefly of service to those whose business is the production of poultry for the market. The poultry dealer, curious though the fact may be, is not at all disinclined to set the fashion in respect of the points of the birds which he sells in the course of his business. He is willing to accept birds of first-class quality, and, what is more, to pay good prices for them, so long as they satisfy his customers.

The Points of the Table Breeds. The chief points of a table fowl are size without correspondingly coarse bone, light-coloured skin, abundance of meat upon the breast, the merrythought, and the wing, well-fleshed and tender thighs, and a small proportion of offal; in a word, the natural requirements of the buyer are a maximum quantity of white tender meat and a minimum quantity of waste. If two specimens, one of a good table variety, such as the Indian Game [5], and another of an inferior table breed such as the Minorca, are selected as nearly as possible of the same weight, and the whole of the meat removed as in the process of boning; and if this meat, on the one hand, and the waste, which includes the bone and all that is inedible, on the other, are weighed, a remarkable difference will be shown on comparison, and the amateur will acquire some very definite idea of the relative merits of the table and the non-table breeds.

Again, if we select an imported Russian chicken, which in the spring may frequently be purchased in the retail shops of London suburbs for 1s. 6d., and make it one of a couple by adding an English-bred chicken of first-class quality, we shall find that when both are cooked and placed upon the table the contrast in the quality as well as in the quantity of the meat is very marked. What it is possible to obtain by skilful breeding and feeding may be ascertained by visiting a first-class Bond Street poulterer's shop, and examining the chickens and capons in the early season, when, as we have seen, they realise as much as half a guinea each. Still better shall we realise the remarkable character of the modern industry by a visit to the exhibitions at the Smithfield and National Dairy Shows, at the Agricultural Hall at Islington, in December and October respectively. At these meetings excessive fatness obtained by the process of cramming is allied to quality and quantity of meat.

The Best Meat Producer. The most fashionable birds for the table as we write are those which are the produce of a cross between the Dark Dorking [3], the largest of the Dorking varieties, and the Indian Game, the male bird of the latter being mated with the hens of the former breed. The chickens which are the produce of this cross are precocious in growth, heavily fleshed, producing meat of the finest quality, and laying on fat when they are crammed for the purpose. If the Indian Game cock be mated with Cochin hens, which closely resemble

Dorking hens in size, although the result is a great improvement upon the pure Cochin, the inferiority of the produce as compared with the Indian Game-Dorking is marked. The excessive quantity of offal and the compara-



2. SILVER PENCILLED

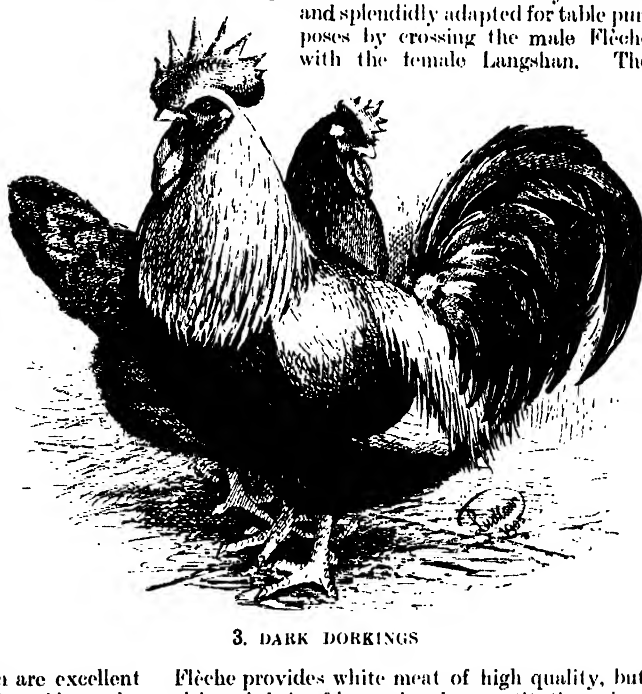
tively small quantity of meat carried by so large a fowl entirely rules the Cochin breed out of the category of table poultry.

How Breeds are Improved. In crossing two varieties, the one naturally supplies in its progeny the deficiency of the other, and we obtain a combination of properties which, if the mating has been wise, is an advance upon those inherent in the inferior breed. In practically all cases crossing improves the constitution and stamina; the chickens are more precocious, more active, and more thrifty, while they display a greater aptitude to lay on flesh and to be ready for market at an earlier period.

It is on almost all occasions advisable in crossing two varieties to select the hens of the larger breed, especially if the eggs are also larger, for the size of the chicken is usually controlled by the size of the egg. Judicious crossing, too, should result in the production of meat of better quality as well as of larger quantity. We have referred to the crossing of the Cochin; the Brahma, also an Asiatic breed, may be taken as an example in another direction. This variety is an inferior table fowl, but mated with the Dorking it produces large robust chickens which are excellent layers and sitters, and which on the table are by no means to be despised.

Plumage and Exhibition Fowls. But, it may be asked, if the Dorking be so superior to the Brahma, why make a cross at all? The answer is obvious, and it applies to many other varieties. Poultry keepers have their fancies, and there are many who keep Brahmas as a hobby, and for purposes of exhibition, but who, nevertheless, require an occasional couple for the table. In such a case it is preferable to mate a separate pen of Brahma hens with the Dorking cock, and in this way, while maintaining the yard of Brahmas practically intact, to secure chickens which will prove much more satisfactory from the economical side. If there be an objection to this plan, two or three Dorking hens may be placed with a breeding pen of Brahmas, their eggs, which are easily recognised owing to the difference in colour, hatched, and the chickens reared with the rest, and killed for the table when mature enough.

Uniformity. There are other cases in which poultry keepers, while not necessarily fanciers of any particular variety of pure-bred poultry, prefer to have something like uniformity of colour and plumage in their flocks. There are some who fancy white plumage; others, in towns and the suburbs of towns, who prefer black. A yard of excellent black-plumaged birds may be maintained consistently uniform and splendidly adapted for table purposes by crossing the male Flèche with the female Langshan. The



3. DARK DORKINGS

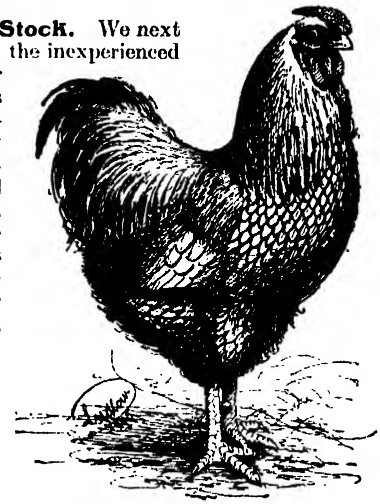
Flèche provides white meat of high quality, but although it is of large size, its constitution when highly bred is somewhat fragile. Crossing, however, with the Langshan results in the production of strong chickens which are large, precocious, rapid growers, producers of large eggs and of

plenty of fine meat on the best parts of the carcase. The birds are handsome, square, hardy, and generally useful. After all, however, has been said, there is no single breed which eclipses the Dorking, either as a table fowl or as a sitter and mother, but the variety is not among the best of layers.

Production of Young Stock. We next come to some questions which the inexperienced breeder must carefully consider in making and conducting his arrangements for the production of young stock. It will usually be found advantageous to mate two-year-old hens with a cockerel bred in the previous year, but where early chickens are essential this may be impossible owing to the fact that adult hens seldom lay in January or even February; thus the breeder is driven to employ pullets of the previous year's hatching in order to obtain what he requires.

It is wise to keep the sexes entirely apart until they are mated. The male birds will be fresher and lustier, while any possible influence which may follow the union of the hens with any other male birds, which might occur should they be at liberty, will be prevented. The number of hens which should be mated to a cock is also a matter deserving some consideration. Where all the birds are free and roam at large, as in a farmyard, one, two, or three males may be found sufficient for a large number, but where they are practically confined to a breeding pen some restriction must be placed upon the number of hens allotted. In the early months of the year the number should be smaller than in later months, as in spring, which is the natural breeding season. A larger number of hens may be placed with a cockerel than with a cock, while as the heavier and coarser breeds are not so prolific as the lighter varieties, fewer hens are usually mated with a single male. Again, it is unwise to mate an active male with too few hens, since their plumage may be spoiled. In the early season six hens may be regarded as sufficient, while a little later two or three may be added, and later still, with vigorous birds of the previous year, the number may be increased to ten or twelve.

Feeding Poultry. It is important, too, that attention should be paid to the feeding.



4. LACED WYANDOTTE

5. INDIAN GAME

If food be supplied in abundance, the hens are certain to obtain all they require, possibly more, and thus over-feeding must be guarded against, as that may interfere with prolific laying. It frequently happens, however, that the male birds will not feed sufficiently well, and when this is the case care should be taken to supply them not only with the grain they require but with occasional morsels of meat, which they cannot pass on to their wives, in order that they may be kept in sufficiently robust condition. High feeding is conducive to early laying and to the production of a larger number of eggs. This, therefore, should be arranged for both sexes, especially for mature hens, but instead of supplying red meat it will be found much more advantageous to provide white meat, which is less stimulating and equally nourishing, and this can be obtained by cleaning, cooking, and mincing the intestines of the sheep or the bullock.

In breeding for the table it is obvious that, on account of their larger size, as many cockerels should be produced as possible. There is no golden rule for the production of an excess of male chickens, but in practice it frequently happens that by mating a lusty cockerel—by which we mean a bird produced in the preceding year—to equally lusty hens which are a year older, and which practically have commenced their third season, success is achieved. It is not precisely known how long the influence of the male bird exists. We may, however, take it for granted that after a week has elapsed between the removal of one male and the introduction of another, the eggs laid by the hens will have been fertilised by the new introduction.

If a pen of birds be too small—namely, if the hens be too few in number—some common hens may be added to bring it up to a normal proportion; but in this case, in order that the eggs may not be mixed and common chickens unnecessarily reared, it will be well that the new-comers should be such as lay eggs of a different colour, or, if this be impossible, that the chickens which are hatched from them should be easily distinguished when they are hatched.

Continued

THE FAMILY AND THE RACE

Marriage Provides the Conditions for the Ideal Family. The Family is the Strength of the Race. Parental and Filial Responsibility

Continued from page 4539

By Dr. C. W. SALEEBY

IT is impossible to consider the subject of marriage and to ignore altogether the extremely important question of divorce. Again we make the observation that, from a purely sociological point of view, divorce in the case of a childless marriage is no more important than such a marriage itself. From the impartial standpoint of our science we are concerned merely with divorce in cases of fertile marriage. It is impossible here to summarise, even briefly, the various laws and customs of divorce which historians of the subject recognise. So far as English-speaking people are concerned, the subject is exhaustively discussed in Professor Howard's great book, which is the standard work on the subject.

The Extremes of Marriage. Let us briefly observe, however, the sociological significance of the extremes of practice in this matter. The one extreme is that which the Roman Catholic Church illustrates, the non-recognition of all divorce. At the other extreme, disgracefully illustrated in some parts of America to-day, we have a facility of divorce so great that marriage really ceases to be marriage at all. It is, indeed, no better than "leasehold marriage," into which the parties may enter with a mutual understanding that it is to be terminated at their convenience. Such marriages, it is true, are very frequently childless, and this fact renders them less objectionable to the sociologist than they would otherwise be. Where they are not childless it is evident that such practices strike a mortal blow at the family, and if they were the general rule of any community, as they are not, that community would certainly soon disappear.

As regards the absolute denial of all divorce, it must be remembered that the sociologist, as a sociologist, entertains an entirely different conception of marriage from that held by the Church. If the Church regards marriage as a sacrament of its own institution, the Church is clearly entitled to judge of its conditions. It has more than this life to think of. The sociologist, however, is entitled to his own opinion upon what he conceives to be a purely secular and social institution, and no scientific sociologist will be found who does not admit the propriety both of divorce and of remarriage, under certain conditions.

The Obligation of Parentage. Comparative students of marriage law are sometimes of opinion that English divorce law is as nearly satisfactory as can be, though we must remember that it is still disfigured by injustice in its comparative treatment of the two sexes. It is unquestionably true that laws of divorce are open to abuse, and have at all times been more or less abused. It is also true that the distinction which the sociologist draws between divorce in cases of childless marriage and in cases of fertile marriage would, perhaps, if legally recognised, tend still further to lower the birth-rate. What is commonly forgotten, however, by those observers who are not acquainted with the fundamental facts of biology is that the process of natural selection or survival of the fittest retains its automatic and ceaseless control over human affairs. Not merely is abuse of the divorce law confined to the few, the great mass of the people being of a moral habit in these respects, but also these few who are cast up by each generation tend constantly towards their own extinction. One of the conditions for the survival of any breed or stock in society is evidently the willingness to undertake the obligations of parentage under the normal conditions of family life. Those individuals who do not comply with this condition are of no further account to the sociologist after their individual lives are ended, and he is the less likely to waste his time in useless reprobation of them if he remembers that their faults provide their own doom, and that, though persons of such a kind have always been produced in all generations and in all civilisations, they are not capable of arresting the progress of the race. This is yet another instance of the beneficent working of that law of the survival of the fittest which, in many of its applications, seems at first sight to be cruel and maleficent.

Marriage is a Means, not an End. We have again and again insisted that our interest in marriage is in marriage as a means and not as an end. Thus we have found the ultimate sanction for the form of marriage practised among ourselves in the fact that it provides the conditions for the ideal family. Now, it is the profound conviction of the sociologist that the poets and the moralists are right in teaching that family life is the first condition for the welfare of any society, and we must discuss this question all the more closely and completely because of the tendency, extremely conspicuous among ourselves, towards *the disintegration of the family.*

Sir Henry Maine, a famous pioneer of historical sociology, laid down the generalisation that "the unit of an ancient society was the family, and of a modern society is the individual." It is a definite tendency of civilisation, as it becomes more complex, to supersede family relations in large measure by external relations, which often take the form, for instance, of direct relations to the State. Not only the complexity of social relations in our own time, but many other causes tend towards the weakening of the family

organism. Conspicuous among these is our modern facility of locomotion. Yet another is the radically vicious custom of married women's labour. Another, in such a country as Germany, is conscription; and yet another in all civilised countries is the interference of the State in education. To these questions we must return, but first of all let us consider the historical reason why the individual rather than the family has come to be the unit of modern society.

War is the Enemy of the Family. A fundamental truth, the consequences of which are amazingly forgotten by some, is that there are more human beings on this planet to-day than there ever were at any period in the past, and there will be still more to-morrow. This great fact of *the constant multiplication of man* has to be reckoned with as perhaps the most potent force in history. If, then, we turn our eyes back to a time when societies were small in proportion to the land which they occupied, and when each society was complete in itself—a period this which is all but prehistoric, though, of course, there are more recent exceptional instances of such a state—we shall realise what the struggle between societies involved for family life. Time was when the son's duty to his father and mother *was* his duty to his society. In obeying them, in learning his father's trade, and in at last supporting his aged parents, he was doing his duty to his society as a whole. There was no conflict of duty. But there began as a general phenomenon of human life the history of that appalling thing which we call war, which we must afterwards study. It is not, at present, our business to ask whether war was or was not inevitable at a certain stage in human history; whether it has not even played a part in progress. Here we are concerned merely to observe that when the state of struggle between societies came to be a normal condition of human life, constantly and everywhere, a great blow was struck at the ancient conception of the family.

Militarism is on its Last Legs. In the first place, there came to be a still more disproportionate appraisement of the relative worth of the two sexes. The little girl-baby could only grow up to be a weak woman, but the little boy-baby would grow up to be a soldier. In the second place, there came to be a conflict of duty. Family life might demand of a son that he should work for his father or help to support his aged mother, but the State demanded that he should go forth to fight. In countries where there is conscription the same opposition still manifests itself—conscription, of course, being nothing more than a modern survival from past times, when every able-bodied man was of chief interest to the State because he was capable of being made into a soldier. Thus we may lay down the general proposition that *militarism and family life are eternally opposed*, and that the modern disintegration of the family has chiefly depended upon the development of military struggle between societies; this, in turn, being mainly dependent upon the fundamental fact of the ceaseless multiplication of man. Militarism, however, despite War-lords and Jingoes, is on its last legs—a fact which the biologist explains in his own language, as we shall see. The struggle between societies persists, as does struggle between individuals, but just as this latter is no longer a struggle of muscle against muscle but of mind against mind, so also the physical struggle called *war* is becoming exceptional, while the main field of battle has been transferred to the psychical plane. Thus the chief historical foe of the family life is nearing its end.

But the reader will ask whether the subordination of the family interest to the State, as classically illustrated by the Spartan mother, who sent her son to battle telling him to return with his shield or upon it, has not justified itself by its results; whether, indeed, the subordination of the family is not, as some tell us, the sign of a progressive society?

Where is Sparta Now? But to this, in the opinion of the writer at any rate, a complete answer is possible. The reader must judge of its value for himself. We have already conceived of history as a series of great sociological experiments, and now we must ask ourselves whether these experiments with the family lead to any positive conclusions. The answer is that they do—for where is Sparta now? Where are the purely military nations? They cannot answer to their names, for they are no more. They sacrificed the fundamental social institution in the supposed interests of society, and the sacrifice involved the ultimate destruction of the society. The purely military nations have a brief record of success, and then their history is a permanent blank. So long as the capital of strength and virtue, which spring from family life, was not exhausted, these nations were successful, but permanent failure thereafter was the price they paid. On the other hand, there is one salient instance which proves up to the hilt, in our judgment, that the great social institution for which we have the warrant of biology must necessarily be upheld by any race that would achieve permanence.

The Secret of the Jews. There is perhaps only one such race in the whole of human history. The modern Greeks, as physical anthropology has shown, are the descendants of the ancient Greeks only in name. The same is true of the modern Egyptians and the modern Romans. One race, however, has persisted—and this despite a measure of continuous and extreme discouragement and persecution and repression to which history offers no parallel. Exiled from their native land; subject to continual massacre; scattered broadcast over the whole face of Europe; the object of repressive legislation for 2,000 years; compelled to live in insanitary cities, so that they have not had the advantage of recruits of peasant blood and peasant vigour; never distinguished in the arts of war—the Jews have nevertheless presented the unique phenomenon of a continuous history such as no other race has been able to achieve, even without the appalling disadvantages under which they have laboured.

Where are we to find the explanation of this fact? It is amongst the Jews that we find the ideal of family life, and this it is which has

nurtured their unconquerable strength. In the first place, they have a very high birth-rate, children being regarded as blessings from God. This high birth-rate they have always maintained; it makes for the production of that kind of family which the sociologist, always remembering that human nature is his key, regards with the greatest satisfaction—the younger children learning certain lessons from the older ones and the older children learning certain lessons by their contact with and duties to the younger ones.

The High Ideal of Parentage. Now, it is the rule that a high birth-rate is accompanied by a high infant mortality, but to this rule the Jews, like the present day Irish, have always offered an exception. This in both cases is directly due to the high ideal of parentage. The Jewish or Irish mother who will not nurse her own children, though she can, is practically unknown. After this early period the care of the children is maintained. Thus, comparative study of the Jewish and Gentile children, in the schools of Leeds, by Dr. William Hall, has lately proved that at all ages the Jewish children of both sexes have a very great advantage in height, in weight, and in physique, the difference being very similar to the difference between board-school boys and public-school boys of similar ages. But the explanation is not exactly the same, for the board-school boy profits not by any high ideal of the family in the class to which he belongs, but in virtue of his parents' means; whereas the Jewish children, despite their parents' poverty, profit by the assiduous care and self-sacrifice displayed by them. Just as a drunken Jew is practically unknown, so there is nothing among the poor Jewish families in any part of Europe which corresponds at all with the fact that one-sixth of the income of the working-class family in this country is spent upon alcohol. We submit, then, as a lesson of history, that the sociological value of the family as the necessary unit of any stable society or race is demonstrated in the amazing case of the Jews.

Science and the Fifth Commandment. It must be remembered that, for the sociologist, the family has two aspects of value. The first, and the most important, is that which is concerned with the upbringing of the children; but the other is expressed in the commandment, of such profound sociological importance, which the Jews have obeyed since it was given to them, "Honour thy Father and thy Mother." This, as has been said, is the "first commandment with promise," and the essence of the promise has been fulfilled. Part of the ideal of the family is that the parents, in their declining years, shall be supported by the children for whom, in time past, they have made so many sacrifices. This certainly is an arrangement to which we see no parallel in the case of sub-human nature, but it is as certainly part of the ideal of the human family, and makes very greatly for the stability and security of any society. We can hardly say that any one was ever encouraged to parentage by the thought that his children would afterwards become the staff of his old age, though it is an interesting fact that this argument has quite lately been employed by those who are alarmed at the declining birth-rate in this country. The neglect to obey this ancient commandment, gravely threatening as it does the ideal of the family, is of the greatest concern to the philosophic sociologist. Probably there is no other commandment so generally neglected by the mass of people at the present day.

The State and Filial Responsibility. Herbert Spencer regarded the care of the aged by the young, who owe them so much, as the most conspicuous instance in which our practical morality needs mending. The recent scientific study to which, as we have seen, social reformers are nowadays lending themselves, has thrown an extremely sinister light upon this very question. We are coming to see that under our modern social arrangements we are doing our utmost to diminish and destroy that sense of filial responsibility which is as valuable a social force to-day, even in our complex state of society, as it was at the foot of Sinai more than three thousand years ago. One or two contemporary facts bearing upon this point may be cited.

Many observers have lately shown that among the gravest defects of our system of outdoor relief, for which the responsible and valuable members of the community have to pay, is its encouragement of filial irresponsibility. A scandalous proportion of the whole sum spent upon outdoor relief is devoted to the maintenance of elderly persons who have children living and able to support them, but unwilling to do so. The legislator must reckon with human nature, and human nature being what it is, we cannot be surprised that a very large proportion of men, forgetful of the benefits they have received, will refrain from supporting their parents when they know that the State will do this for them.

A Lesson for England from Japan. A similar theoretical objection applies to any hasty and ill-considered scheme of old-age pensions. In considering such a scheme it is at least right that we should steadfastly hold before our minds *the ideal*—which unquestionably is that in the case of aged persons who have living children able to support them, the support should come from that source. And the further question must be asked, whether we are not weakening the sense of filial responsibility, and therefore complicating the problem of the aged, by all such measures as weaken *parental* responsibility, causing children to be cared for by others than their parents, and therefore diminishing those feelings of filial gratitude to which, in an ideal world, the aged parent would not have to look in vain?

In Japan, as in some other parts of the world, the ancient fear and worship of the spirits of the departed has gradually developed, as students of religion tell us, into a form of ancestor-worship that has many beautiful and moral features. Now, wherever we find such ancestor-worship we have to recognise its value for family life. It leads

to an extremely healthy reverence for the aged, and especially for parents. Practical proof of this is easily forthcoming. The population of Japan is much larger than that of Great Britain, but in that country there are yearly relieved only 30,000 paupers, as against very nearly a million amongst ourselves. But in Japan the young man puts aside, from his first wage-earning days, a small sum towards the future support of his aged parents. In a land of ancestor-worshippers this is recognised as the very first duty of every decent son, and the statistics of pauperism show the consequence. It was not of Japan but Great Britain that Herbert Spencer spoke when he said:

"The last to show itself, among the bonds which hold the family together—the care of parents by offspring—is the one which has most room for increase. With the strengthening of intellectual and moral sympathy, the latter days of life will be smoothed by a greater filial care, reciprocating the greater parental care bestowed in earlier life."

The Cradle of all the Virtues. That the phrase *parental responsibility* corresponds to a great reality no biologist or sociologist can question; but, unfortunately, it has been so greatly abused in recent times that it would almost be well if some new term could be invented. The value of parental responsibility has been quoted again and again by a certain school of thinkers as a sufficient reason for permitting children to starve. The argument apparently is that we are to punish and reform the careless parent in the hapless body of his child, though it would appear a reasonable argument that, just because he is a careless parent, this method is not likely to reform him. There is no sociological warrant for the argument that it is worth the while of any society to injure the rising generation in order to uphold the doctrine of parental responsibility. Unfortunately, it is arguments such as these that have cast the whole conception into discredit, and therewith the true conception of the family. Thus it is possible for the Countess of Warwick to refer to this conception as "some malignant eighteenth century theory," and to speak of "the fetish of parental responsibility," so that the truth which the phrase expresses has become discredited.

It is well, then, for us to realise that *the family* and *the home* necessarily depend for their integrity upon the realisation of the idea for which this phrase stands. No one would dare speak of "the fetish of the home"; the good sense of the people would not tolerate such a phrase. In serious argument with serious and intelligent people it is always possible to obtain a full and free admission of a plea for the family and home life as the cradle of all the social virtues and of worthy character.

Why the Well-to-do Classes are Disappearing. Once this is admitted, it does not require much reflection for anyone to see that the idea of parental responsibility is inextricably involved in any true conception of the family. Postponing for the moment that part of our argument in which finance is involved, and which therefore arouses our unscientific passions, let us first of all consider this question of parental responsibility as it practically affects the well-to-do classes. We shall find that there exist, and have long been patronised, various means by which the family and the home may be weakened and parental responsibility ignored, even in these classes of society. We may, or we may not, according to our judgment, correlate these facts with another fact of the most serious kind to every sociologist—namely, that society is an organism which recruits itself from below. The well-to-do classes constantly tend towards extinction, and are kept in existence only by constant reinforcement from the classes beneath them. This may or may not be a general law of all societies; it probably is. If, however, we believe in heredity, we cannot but deplore the working of any law which seems to select the fittest and most capable, the most original, industrious, and intelligent from the mass of the community and, after making them into a special class, leads to the extinction of the valuable stocks which they represent.

Neither the psychologist, the sociologist, nor the educationist can regard with satisfaction the institution which is known as the boarding school. It is, of course, an obvious necessity, though in the nature of a last resort, for orphans, children whose parents are compelled to live abroad, and those whose parents are themselves ignorant and undisciplined, and therefore incapable of teaching or training their children.

A Grave Indictment of the Boarding School. But in controversion of the general assumption that a boarding school is the proper place for all boys and girls whose parents have sufficient means we may quote two authoritative and recent opinions. The first is that of one of the greatest living students of the mind, in health and disease—Dr. T. S. Clouston, of Edinburgh:

"Unquestionably the ideal mode of education for both sexes, were all parents wise and firm and intelligent, and had they plenty of time and opportunity to devote to their children's upbringing, would be home life with day-school teaching. No one will convince me that the accumulated wisdom which the parents have acquired, and the family ties and amenities of home life are not the best educative influences. I have no doubt whatever that the general intelligence of the educated classes in England has suffered greatly through so many of its boys and girls having lived a monastic life away from home for most of their time. It is always to me pathetic to consider the way in which the boys at Rugby were influenced so much for good by Dr. Arnold, when I think that hundreds of those boys must have had parents at home almost as wise as Dr. Arnold, quite as good in the example of their lives, and far more interested in them. Education plus affection exhibited in daily life must surely be a better thing than education minus affection and minus intense personal interest. The widely held assumption of English parents that their duty has ceased, and that of the schoolmaster begins, when their children reach eight or nine years of age seems

to me an essentially selfish notion. It implies an incomplete conception of fatherhood and motherhood." ("The Hygiene of Mind," Methuen. 1906.)

Artificial Societies. More serious still, perhaps, because of the peculiar position of the author, is the following quotation in which Dr. Gray, the headmaster of Bradfield College, briefly and unanswerably condemns—though he remains himself quite unaware of the condemnation—the essential facts of boarding schools. "It must be remembered," he says:

"(1) That we have to deal with a society of immature minds and plastic morality;

"(2) That this society is *artificially* constituted—that is, it does not proceed on the lines of family relations, which Nature intended should be followed throughout life, but is isolated and 'monastic.'

"Here, then, at the most critical stage of a boy's life, at a time when, along with violent physical changes, the character is being formed with at least equally startling rapidity, when reason is often comparatively weak, and sentiment and emotion are always strong, a boy is taken away from the formative influences of the other sex, from the mother and sister, and thrust into a community composed of one sex only, where all do the same things, think the same thoughts, and talk round the same confined circle of subjects." ("Hibbert Journal." July, 1906.)

Unfortunately, a much graver indictment even than anything contained in the above quotation may be made against boarding schools, but that is not strictly relevant to sociology. It is worth briefly noting, however, that one of the cardinal objections to the boarding school, the unnatural isolation of the sexes, is removed by the practice of co-education, which, though it still seems startling and dangerous to us, has been found highly successful wherever it is practised, as, for instance, in the United States.

A Fatal Blow at Family Life. The decadence of parenthood, both of maternity and paternity, which is so conspicuous in the upper classes and of which their vanishing birth-rate is the most fatal indication, remained of relatively small importance so long as family life throve unvitiated in the most vital part of society—in those classes whose birth-rate is high, and from which the "higher" classes are ever reinforced. Fundamentally bad though the boarding school system may be, at least its influence was confined to a relatively small section of society. But there now arises the question whether something like the same system is not threatening to introduce itself even amongst the masses of the people—from whom the next generation mainly springs. Now, the pivot of family life is the mother, and though we must leave to a subsequent chapter the systematic consideration of the place and function of woman in society, we must here consider the woman as mother in her relation to the family. It is certain that the employment of a wife and mother in a factory strikes a fatal blow at family life, and from the point of view of any sound sociology is a fundamentally vicious practice. We are not here concerned with its financial aspects, though it is worth while to note, in passing, that the combined wages of husband and wife in such cases are very frequently found to be no greater than those of the husband alone in cases where the wife confines her activities to the supremely important work which she alone can perform.

The Destruction of Childhood. Quite apart from this question, we have to consider the effect upon society of this blow at the family. The results are best expressed in terms of the infantile mortality.

When we make inquiry into the condition of those towns, such as Burnley, Preston, and Blackburn, which show the highest infant mortality, we find that these are the very towns in which the percentage of women who work outside their homes is highest. Dr. Newman has gone most exhaustively into this matter, and has proved this up to the hilt. He says, "Broadly it is true that to whatever town or district we turn the same general conclusion is inevitable—*viz.*, that where there is very much occupation of women away from home there will be found, as a rule, a high infant death-rate." His chapter on the Occupation of Women in his recent book on Infant Mortality constitutes as serious and as painful reading as is to be found anywhere.

The Supremacy of Motherhood. We have chosen the infant mortality as the most expressive index of the injury to the family, and therefore o society at large, caused by married women's work. We cannot here discuss the larger question of the effects upon the female organism in general, upon its supreme functions, and therefore upon society, of physical labour such as men can undertake. But it is possible to say, without the smallest qualification, and in the earnest desire to emphasise the gravity of the proposition, that *the factory employment of married women is an outrage against Nature*, an outrage against children, an outrage against the family; and that no industry or apparent prosperity which depends upon it is worth while. In time to come it will be regarded as a mark of the shameful social state of our age, and of the wicked carelessness with which it defied the laws of Nature, that wives and mothers should be employed as beasts of burden, doing the work which a man or a horse or a dynamo can do, while their children were allowed to die at home. It is the lesson of history that blasphemy against motherhood is, for societies, the unpardonable sin, and never were there any truer and worthier words spoken by any statesman in the whole of the past than those which Mr. John Burns addressed to the Infant Mortality Conference last May: "We must glorify, dignify, and purify motherhood by every means in our power."

Continued

MULTIPLE NEWS MESSAGES

Quadruplex Instruments and their Working. News Wires and Press Messages. Classified News

By D. H. KENNEDY

The Quadruplex. We have dealt with the duplex system, in which two messages can be sent in opposite directions at the same time. There is another system called the diplex, in which two messages can be sent simultaneously on one wire in the same direction. It is rarely used, but is sometimes installed when all the traffic between two stations is in one direction. Duplex and diplex have been combined in the quadruplex [13], by means of which two messages in each direction can be simultaneously telegraphed.

Balancing a Quadruplex. So far as the operating is concerned, the *quad*, as it is called, corresponds to two duplex circuits, one of which is called the A side, and the other the B side.

The principle will be dealt with in another section, but, as in the case of the duplex, it is possible to give instructions for balancing and adjusting. The procedure is as follows. The controlling office requests the down station to "earth." For this purpose a two-way switch is provided at each station, which, on being turned to the right, cuts out the batteries, substituting a resistance coil. The balancing of the circuit is now proceeded with on the same lines as in the case of the duplex, using the A side key with B key held down, and adjusting both rheostat and condenser until the needle of the galvanometer remains steady at zero, and no false marks are received.

If necessary, the home station apparatus and batteries may now be proved by withdrawing the 4,000-ohm plug. This will cause the galvanometer to deflect to the left. Now press the A side key. This should reverse the deflection on the galvanometer, and register a signal on the A sounder. Depress the B side key. The galvanometer deflection will increase, and a signal will be registered on the B sounder. Now send on the A key. Corresponding reversals should be observed on the galvanometer and signals on the A sounder. There should be no clicking on the B sounder, which is being held down by the continuous depression of the B key. If clicking occurs, it can be remedied by the judicious adjustment of the B relay and sounder, usually by increasing the spacing bias on the relay and reducing the spring tension on the sounder.

Now send on the B key only. The left deflection of the galvanometer will be increased by each depression of the lever, and corresponding signals will be heard from the B sounder. Finally, work both A and B keys, and observe signals on the related receiving instruments. The 4,000-ohm plug should now be replaced, and the distant station told to "cut in." He will return the two-way switch to the left, and his action will be indicated by the immediate appearance on the up-station galvanometer of a "left" deflection, due to his "*spacing*" current.

The up station will now "earth," to allow the down station to balance. After balancing it is good practice for the stations to take readings from the galvanometers of each other's currents, to ensure that the respective A currents and B currents correspond in value, and that the right proportion between A and B exists.

Standard Practice. The standard procedure is as follows: Observe the "spacing" deflection at normal. Ask the distant station to close A key (the abbreviation C A is used). Take a note of the galvanometer deflection, which should correspond with the spacing deflection. Now say "C B" (close B key). Take the reading of his increased, or B, current, and say "R A" (release A). Observe reversal of big current, and then say "R B" (release B), which completes the process for one station. It must then be repeated in the opposite direction, and the results compared.

These instructions have been written as applying to an increment quadruplex, in which the depression of the B key increases the current. By reading "decrease" for "increase" throughout they apply equally well to a decrement quadruplex, in which the B key decreases instead of increasing the current.

Faults due to "earth" on line and "disconnections" affect the quadruplex in the same way as the duplex. The former is, however, much more sensitive. A steady partial earth, through which a duplex would work, will often make "quad" working impracticable. The leakage has the effect of reducing the difference between the A and B currents, so that the B relay fails to respond. Duplex working on the A side is resorted to. On "increment" sets, if the fault is very pronounced, the whole battery is brought into play by permanently depressing the B key at each end.

News Distribution. It is fortunate, in a sense, for the telegraphic administration that the messages on short suburban and local lines are usually of a very simple character. They are an admirable training ground for the novice, who probably has no special difficulty, unless it is in deciphering the betting messages which unhappily bulk so largely in our telegraph traffic. He must, however, be well advanced in his novitiate before he is allowed to take part in the news work, to which we now turn our attention.

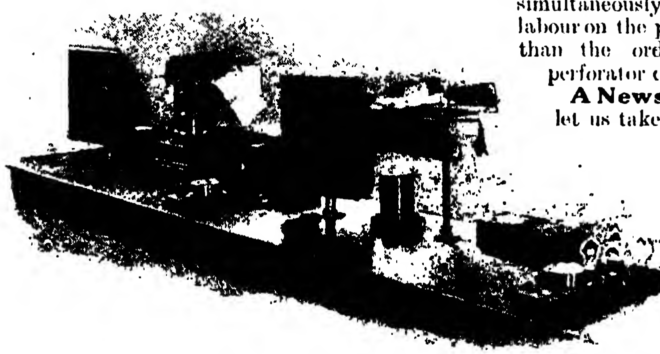
The methods adopted for dealing with news are entirely different to those employed in

ordinary public message work, and this is due to causes which are somewhat interesting.

Press Rates. The predominating cause is the system of charges, or rates, applied to news telegrams. The ordinary day rate is one shilling for 75 words; this applies between 6 a.m. and 6 p.m. In order to provide inducement for news telegrams to be sent at night, when the wires are free from commercial work, the 6 p.m. to 6 a.m. rate is 100 words for one shilling. Second and subsequent copies of the same telegram are delivered to additional addresses *in any town* at a charge of *twopence* per additional address. The italicised words have had a wonderful effect in reducing the cost of Press telegrams and in concentrating the distribution of news into the hands of a few powerful organisations. This will be better understood if we take a case and consider it.

Let us suppose a Press message containing a text of 100 words is handed in for transmission to 100 newspapers. We will suppose each address consists of three words. The cost will be calculated thus

	£	s.	d.
Text 100 words, and addresses, say, 300 words; total, 400 words at 1s.	0	4	0
99 additional copies at 2d.	0	16	6
Total cost	£1	0	6



13. QUADRUPLEX CIRCUIT

Now, if we divide this total cost of 20s. 6d. by the number of newspapers, we find that the average cost of transmitting and delivering the message of 100 words to each newspaper is 2·46d. or under 2½d.

News Agencies. The four principal Press agencies are the Press Association, Central News, Exchange Telegraph Company, and Ivan (Ashley & Smith).

The first three deal with all classes of news, the last-mentioned deals only with sporting reports.

News Wires. London is, of course, the natural centre of news distribution, and on the accompanying map [14] is shown the fourteen principal news distribution circuits radiating from the metropolis. Altogether 33 cities and towns have permanent news wires, while 13 of these—namely, Aberdeen, Birmingham, Bradford, Dundee, Edinburgh, Exeter, Glasgow, Leeds, Liverpool, Manchester, Newcastle, Nottingham and Sheffield have two wires each.

These are the normal circuits, but it is, of course, frequently necessary to supplement these at night by making up additional circuits from wires which during the day have been used for commercial work, and during parliamentary sessions the number reaches 45. One effect of the multiple address rate is visible in the fact that the circuits are of the omnibus kind, several towns being grouped on one wire. The apparatus used is the wonderful Wheatstone automatic system. It is specially well adapted to the peculiar conditions.

As the traffic is all in one direction the transmitters are at the London end, while the outstations are provided with receivers. Keys and sounders are included at all stations to provide for communication between the operators. The perforators at London are specially arranged so that by using pneumatic power several slips can be prepared simultaneously and with less labour on the part of the operator than the ordinary mechanical perforator demands.

A News Message. Now let us take the simplest case. Suppose that a Pressman hands in a despatch containing, say, 60 words, addressed to a provincial newspaper. The charge will be one shilling. It will be sent by pneumatic tube to the news division, recorded by a news distributor and passed to a puncher. He will proceed to prepare a slip beginning with the prefix (which will be "S P"), code, name of sender, "Address to," and then follows the texts.

In the text abbreviations are used freely. Indeed, this applies throughout to news messages and to the Pressmen as well as the telegraphists. On completion the perforated slip and the message sheet are handed to the key clerk. He calls up the distant office by signalling its code three times and adding T S, the code of the London office. Without waiting for a response he switches on the transmitter, inserts the slip under the wheel and allows it to run through. This done, the transmitter is switched off, the signal . . . —— . sent by hand, and the reception acknowledged by the outstation clerk, who signals the code of his office, followed by . —— . —— . .

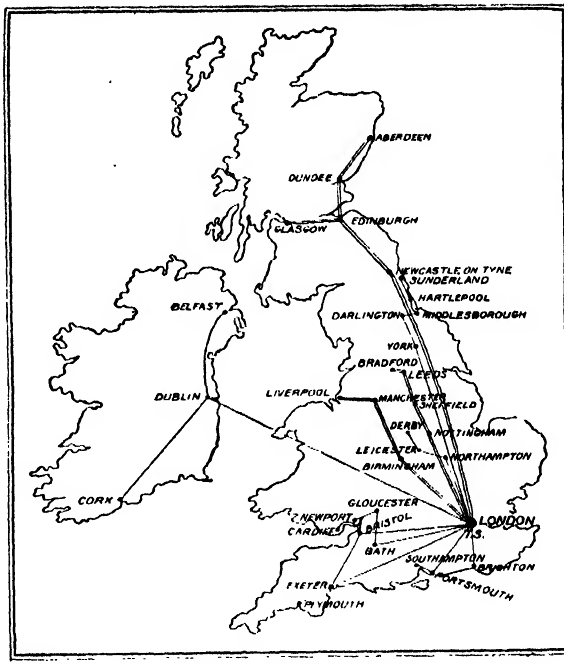
Classified News. Between the four Press agencies already referred to and the department closer relations have been established than ordinarily obtains, and as a result a system of classifying news has been instituted, which considerably simplifies matters for all concerned. One instance will typify the general lines.

The Press Association arranges with its newspaper subscribers to supply to them each day items of general news under the classified heading:

P.A. Midday Special.

Each month a list of the newspapers entitled to this service is furnished to the Post Office, and the various provincial cities and towns concerned are duly advised that all "P.A. Midday Specials" are to be delivered to certain newspapers.

Now let us follow the course of one of these despatches. It reaches the news division by tube in a special envelope with space for initials, so that its progress from point to point may be recorded. It is written on flimsies, and there are about six copies—duplicates prepared by the ordinary carbon process. The envelope is opened by a clerk in the news distribution branch, who marks on the copies the codes of the towns to which they should be transmitted. The despatch now goes to the puncher who prepares the slips. It would be possible to use only one slip and pass on in succession through all the transmitters, but this would cause delay, and, moreover, the slips deteriorate if used too much. It is usual to run one slip through two or three instruments, and the marking of the towns on the duplicates is arranged with this end in view. Arrived at the transmitter, the method is a repetition of what has been described for a single address, the only modification being the calling and the use of the "C Q" signal when all stations are required.



14. NEWS CIRCUIT ROUTES

At the Receiving Stations. The slip is taken off by the key clerk and handed to one of his "writers" along with the sheets on which it is to be written. In front of the key clerk is a notice board on which the titles or numbers of all classified news are displayed, and after each a figure which indicates the number of copies required.

For instance, if P.A. Midday Special is to be delivered to three newspapers the figure will be four, and he will hand out what is called a "top four." It is made up of four flimsies and two carbons. The top sheet is ruled and the under sheets plain.

The writer transcribes the slip and places the sheets on the wire basket near him, from whence it is collected by the messenger boy and conveyed to the news distributor. This officer also has a notice board showing the classified news, but in this case it gives the names of the addressees and so enables him to select the proper printed envelopes and send the news to the delivery department for the messenger or to the newspaper by pneumatic tube, as the case may be.

Long Messages. In every case where a news message is longer than one sheet it is paged and signalled as page one, page two, etc, and in the course of transmission it is split up and no order is observed at any intermediate point between the news distributors in London and the news distributors at the provincial offices. On the former devolves the duty of marking the pages so that the latter will be enabled to piece together the fragments. When this has been done the complete despatch, or some complete portion of it, is issued to the addressee. In the case of long speeches the despatch is divided into lettered sections, each section containing anything up to ten or a dozen pages, but in every case the parts are assembled by the provincial news distributor and put in regular order for delivery.

Continued

THE FREE-LANCE IN JOURNALISM

A Career Calling for Courage. The Temptation of London. How to Read the Papers. Editors and Contributors. Why Articles Come Back

By ARTHUR MEE

THE man who succeeds in journalism as a free-lance holds one of the most enviable positions in the world. He is tied to neither time nor place. He can work where he will, when he will, as he will. If he lays his plans well, and organises his life well, he may live an almost ideal life. He has the happiest position in journalism. Others may prefer to be editors, with all the anxiety and potentiality for sleepless nights that editing brings, but the free-lance has the success of journalism without its worries, its influence without its penalties. For the ideal journalist the freedom of the free-lance is the ideal life.

Always at His Best. We have made up our minds what the ideal journalist should be, and the free-lance must have his qualities in ample abundance. There are some qualities that are specially his. He lives a life of great intensity, which will admit of no dissipation of energy, which insists upon method, regularity, punctuality, and application There is no severer test of a good journalist than six months as a free-lance, and no man who is a bad journalist survives the test.

The successful free-lance is invariably a good journalist, because his success is the result of the work of his brain, and is not due to any of the varied circumstances that may keep a merely mechanical journalist in regular employment inside a newspaper office. The free-lance has a barometer for testing the quality of his work which never fails him. His income depends entirely upon his keeping up to the mark, and the freedom which he has given himself in his career is a discipline which must be constantly making him a better man and a better workman. He can never say to himself with impunity, as, perhaps, the regular journalist can, that he will not take much trouble with this, or will quickly dispose of that, or will neglect the other altogether. Such things spell ruin for him. The free-lance journalist must be always at his best.

A Rare Courage. And, because of this, he must have a courage that is one of the rarest things in the world—the courage to cut off his income at any moment. He will find that the strain is at times greater than he can bear, and there is only one penalty, as tragic as it is sure, for the man who neglects the warning that Nature always gives in time. No man should rely upon a free life as a journalist who is not prepared to face the risk of having to stop his income for a week or a month or a longer period at the bidding of a master who cannot be disobeyed. Let us go further, and say that no man should rely upon a free life as a journalist who cannot establish himself upon a foundation so strong that he can lay aside his work for a time without running the risk of losing it. The man who holds his work by the quality of it need not trouble greatly about resting from it. Yet this is one of the chief perils of free-lance journalism. To take a holiday means to be for the time without an income, and, even when the normal income is great enough to allow it, this course is not easy to contemplate. But it is one of the first things that a man must be prepared to do when he sets out upon a career in which freedom can only be enjoyed at freedom's price.

Chief, perhaps, of all the practical essentials to success as a free-lance is method. The free-lance journalist must be prepared to write about anything at any time, and only method can make this possible. This subject, however, is considered fully in the final article in this course, on the Journalist's System. We need only discuss now some of the more obvious ways and means by which the free-lance may establish himself.

An Intimate Knowledge of Papers. The first thing that he should do is to make himself familiar with the papers for which he wants to write. It is amazing how often this essential condition, surely the simplest and most obvious thing in the world, is disregarded. A man who thought a great deal more of himself than his capacity justified called upon an editor the other day for an introduction to another editor. "I used to see his paper fourteen years ago," said the remarkable young man, "but I have not seen it of late years, and I should like to write for it." "Then the best introduction I can give you is to the nearest bookstall," said the editor: and he was perfectly right. It is impertinent to expect to contribute articles to a paper with which one is not familiar, and the free-lance would do well to make up his mind for which papers he would like to work. He will find the field wide and varied, and open on every hand; and he will find that there is no safe guide through any part of it except his own ability and the experience of those who have been that way.

It is assumed in this course that what is wanted is to know how to begin at the bottom rather than what to do at the top, and no attempt is made here to help the journalist who knows his business. And, assuming that our journalist is a beginner in free-lance journalism, all that is attempted here is to help him to set his feet firmly on this broad highway. Two things should be said. Unless he has had newspaper experience, a young man would be unwise to depend upon free-lance journalism for his bread-and-butter; and even with a newspaper training the journalist may make the most serious mistake of his life by leaving a sure and steady post in a provincial town for a less steady but more brilliant post in London.

Those who have read this course so far have not found in it any great sympathy with the timidity which holds men back on the verge of great opportunities, but it is well to utter a warning to those journalists who, succeeding well on a quiet provincial paper, imagine that all they have to do to distinguish themselves and win fortune is to take a single ticket to King's Cross and pick up gold in Fleet Street.

The Provincial Journalist's Temptation. It is the saddest of delusions, and a great book could be filled with tragedies that had no other beginning than this. It cannot be repeated too emphatically that the conditions of journalism in London are utterly different from the conditions outside London, and if it is possible to frame any piece of counsel likely to be applicable to all journalists, at all times, in all circumstances, that counsel is never to give up a post in the provinces to come to London unless a definite post is offered; never, in response to any persuasion, to let go a bird in hand in the provinces for two birds, or even for three or four birds, in a London bush. The writer could tell of many journalists who left provincial newspapers to come to London. Three occur to mind at the moment who came to London within a few years of each other from the same provincial town, each of whom has an income to-day greater than any he could have obtained in any possible post in the provinces. But each of the three came to a definite post, with no kind of risk except the risk common to any change. There comes to mind, on the other hand, the case of the only man the writer knows who came to London without a secure post. He made friendships which brought him influence, but no journalist in this world has ever succeeded entirely through influence, and his career is a failure.

This course is not for the man who can fling defiance at probabilities, or for the born journalist who needs neither help nor warning; but the journalist inclined to risk coming to London with no other support than an empty optimism and the example of somebody else will be wise to heed this counsel and let it give him pause.

What to Write and Where to Send it. Arrived in London, the journalist will order from his newsagent an abundant stock of newspapers and magazines, and will consider no time lost that is spent in reading them. His own instincts will guide him to the right papers. If he will spend a shilling at a bookstall every week, keep a close eye on the magazine departments of the halfpenny newspapers, and study all the London evening papers intimately, he will soon come to understand the kind of copy editors are waiting for. It would fill far too much space to make an adequate list of papers and the kind of articles they like, but there is a much better reason than this for not doing so. The journalist who needs such a list had better at once give up the attempt to earn his living as a free-lance. He has missed the great essential. It is the very first condition of his success that, having written his article, he shall know where to send it with the utmost probability of success.

He may find, however, that his difficulties begin long before he comes to send in his article. He may be puzzled, though it is greatly to be hoped that he will not, by the thought, "What shall I write about?" It is to be hoped that this problem will not trouble him, because there is no excuse for the journalist with nothing to write about. It is the unpardonable sin. The true journalist has always more subjects than he can deal with, and by a process of elimination makes up his mind which to use. Many considerations will influence him in making this decision, varying according to time and circumstance and the character of the paper for which he writes. But if he knows how to read the papers, and where to put his hand at once on material, he will find there is no famine in the Land of Good Copy.

Notes from a Morning Diary. Let us take up the first morning paper that comes to our hand and see what a rich harvest it is to the man who has a fountain-pen, a pad of paper, a good library, and an alert mind. It has in it the potentialities of a hundred articles, and only a few ideas are set down here, exactly as they come to mind in a ten minutes' glance at the paper. They are set down without any attempt to "dress them up" or "round them off," and they pretend to be nothing but what they actually are—the rough mental notes of a journalist on going over a morning paper.

When a New Idea Comes into the World. How a new invention or the discovery of a new system kills an old one; the remarkable commercial effect of the change—suggested by a paragraph announcing the cancel of Government orders based on a superseded system.

The Unseen Wealth of the Church. An article on the mineral royalties on ecclesiastical property—suggested by a paragraph on the estates of the Bishopric of Durham.

The World's Unrealised Debt to England. "When England intervenes"; behind the scenes in diplomacy—suggested by a speech.

How a Groom made £100,000. A public calamity which a clever man knew how to turn to his own good—suggested by a will.

Immortal Nobodies. A shoemaker who fooled a nation, and a host of other cases—suggested by the trial of "Captain" Koepenick.

How Many People Earn £1,000 a Year? Where they earn it, and how—suggested by the report of the Commission on Income Tax.

The Hidden Perils of all Our Lives. The dangers we run in everyday life but rarely think of—suggested by the breaking of a wire on an electric tramway.

A Vision of a New World. A forecast and a reality in the new science; a glimpse of "a totally new and unexpected world"—suggested by a speech of Sir William Huggins.

The Aladdin's Lamps of the British Empire. The great commercial potentialities of the Empire, and the way to realise them—suggested by a picturesque phrase in a speech.

Have We Two Personalities? The power in us that sleeps when we wake, and wakes when we sleep—suggested by a law case and a story of drawings made under "influence."

Do the Rothschilds Earn Their Income? Or is it unearned increment?—suggested by the Income Tax Report.

"Thinking Out" a Battleship. The incredible marvels of battleships—suggested by the death of a man who designed battleships for half the navies in the world.

Rich People with no Use for Money. The extraordinary things they do with it—suggested by a curious story of hidden money.

Nothing is Old Under the Sun. So, if we had space, we might go on, fascinated by the ideas that leap to us wherever we turn. We have glanced rapidly through one paper, and there are a dozen papers, *all different*. It is important to the journalist not to make the fatal mistake of thinking, as the public is apt to think, that all papers are the same. In their appeal to the mind no two papers are the same. There may be a world of difference in the way in which two papers put the same thing, and the same thing put in different ways may bring quite different ideas to the mind.

Many years ago, a House of Commons gallery man called one night at his old office in a Midland town, and the junior member of the staff manifested a keen interest in what he had to say about life in the House of Commons. It was all new to him, and the conversation opened up a new avenue of interest. "I will write an article about it," he said. The older men laughed. "These young men don't know that all this has been done before," said a sage sub-editor, who had sub-edited telegrams at the same desk for forty years. "I understand that quite well," said the junior reporter. "It is all very commonplace to you, but it is new to me, and everything depends on the way it is put." The sub-editor sat at his desk until, in the fulness of time, he died; the junior reporter rapidly rose to be an editor in London. The junior was quite right. Nothing is old under the sun. One man's knowledge is another man's news, and, even to the man who knows, the subject may be presented with all the freshness of a new outlook and a virgin enthusiasm.

"Everything has been Done." The population of London is six millions: how many articles, one wonders, are there in that fact? How many books have been written out of it? It is a fact that everybody knows, yet it is a fact that can be written about by a thousand men in different ways, or by one man in a thousand ways, without ever wearying us or driving us to say "I knew that before." There is nobody so hopeless as the man who discards a subject merely because "it has been done before." If the subject had any inherent interest yesterday, it has the same inherent interest to-day. There may, of course, be a hundred reasons why it need not be written about to-day, but the fact that it was written about yesterday is no reason at all.

It is the superficial journalist who, seizing upon the obvious and ignoring the deeper interest, gives way to the feeling that "everything has been done." Everything has two interests; every substance has its shadow; and there is a journalism of shadows and a journalism of substances. One of the cleverest journalists the writer knows was once in one of the most beautiful rooms in Europe. There is probably no room anywhere with a greater number of interests from a greater number of points of view. One of its interests is a diamond—a dazzling thing of transcendent beauty which has figured in the history of Europe, and is stained with the blood of many wars. It is an experience to have looked upon a thing so historic; it is an asset in every journalist's career to come in touch with people and places and things that have made or have been used in the making of history.

The Journalist's Interest in Realities. But it is easy to make a mistake here, and our clever journalist made it. He sacrificed the substance for the shadow. He spent all his time in looking at the diamond, and the thousand other things made no impression on his mind. Yet they were of equal interest, and it can hardly be doubted that a general impression of the room and its contents as a whole would have been a much more valuable contribution to the mind of the journalist than a much stronger impression of one thing in the room. And the journalist was doubly wrong, from our point of view, for he was interested in the diamond because there is a story *about* it, because of an *accidental circumstance*, and not because of anything *inherent in the diamond itself*. It would not have mattered, so far as the impression on him was concerned, if the diamond had been another diamond, or even a piece of clay, since what impressed him was not the thing he saw, but a story that it brought to mind; and the lesson of this is that our gain is all the greater if we are interested in things intrinsically rather than in things for their associations' sake. The journalist's interest in the diamond will pass away, because his lasting interest is not in the gem, but in a story about it; and the gain to him of his visit to the Louvre will pass away to that extent. Had his interest been excited in the diamond as a thing of wondrous beauty, it would have remained with him. As it was he left without any adequate impression of the vast intrinsic beauty of the room, its abundance of treasure, its wonder of craftsmanship, its amazing collection of things all as compelling as that little bit of it which he allowed to steal away all his time.

A Sound Foundation of Knowledge. The example will not have been quoted in vain if it helps us to appreciate the vast difference between a thing itself and its associations. That does not mean, of course, that the associations have no legitimate interest for the journalist. On the contrary, he is the best journalist who knows most of these things, who knows all the stories and incidents and accidents and circumstances which make up the environment of all concrete things. The point of all that has been said is, not that the story is uninteresting or even unimportant, but that the wise journalist fixes his interest in the things themselves rather than in their associations, in things that are permanent rather than in incidents that pass; that his knowledge is at the root rather than hanging on the branch.

If his foundation is thus sound, he can erect any superstructure upon it, and the more varied the superstructure is the more certain his success as a journalist will be. With his interest thus fixed in the substance, he will miss nothing that is interesting in the shadow, and he will find that the day never comes when there is nothing in the papers for him to write about.

The Ideal Contributor. His subject found, his article written, and his paper in mind, the next interest of the free-lance is to reach his editor. Here the simplest advice is far the best. He should send his article to the editor in the ordinary way. He need not bother about introductions. If he can get them easily so much the better, and as a means of reaching an editor an introduction is often useful; it sometimes sets up a connection which might otherwise take a long time to establish. But that is all that introductions can do. Nine introductions out of ten only annoy an editor, and introductions have ceased to have much weight because they are too often used by those who have no merit of their own to introduce them. It may be taken as universally true that an editor has much more esteem for the contributor who sends him a good article than for the would-be contributor whose first excuse for calling or writing is that he knows somebody who knows the editor.

An interesting article might be written on how to manage an editor, but we can do no more here than give one or two hints. We have been considering all through this course ideal journalists and ideal papers; let us consider for a moment the ideal contributor. He has behind him a system such as we shall come to consider in due course, enabling him to write on any subject at any time. He is always available, always reliable, always prompt. He does not worry the editor with unnecessary letters or ask him to wire if he accepts an article. He regards an editor as a gentleman, and does not intrude into an editor's room, as a journalist bearing a well-known name did the other day, violently demanding an explanation why an article sent the day before had not been returned. He does not ask an editor to verify quotations, or to post an article on to another paper if his own paper cannot use it. He does not call himself "Author and Journalist" on his notepaper, or put "M.J.I." on his card, or address himself "Esq." on his return envelopes. He does not write "Will you look at an article if I knock one up?"

MS. He knows how to prepare an article. He uses thin paper of a regular size, easy to handle. He types neatly without many corrections, and sub-edits his manuscript with care. He belongs to the very, very small number of journalists whose copy an editor can send straight to the printers. He does not send out stained or crumpled manuscripts, or spend much time in explaining his talents in general or his reasons for writing one article in particular. He does not trouble much about money, and rarely asks an editor how much he will get for an article. He is in search of reputation and connection, and, however poor he is, these things are more to him than cheques. He never refuses to do an article if he can help it. He never writes such disgraceful letters as these:

"Hearing that you are the editor of a new publication, I wish to ask if you require a writer to do a few columns weekly. I did a page of birthday news weekly in the ——— (a dead paper). Many of my dates have only been secured by personal application. I find amusement sometimes by printing the wrong dates and noticing which other birthday writers crib them and give themselves away. You will find it advantageous to retain me. I can do anecdotes about anybody."

"January 21st: On the 12th inst. you received a story from me entitled 'When We Two Went Maying.' As I have not received it back, I presume you are going to make use of same. Let me tell you that you cannot do so without first sending on a remuneration for same. Shall expect either one or the other within the course of a day or two. If I do not, shall put the matter before a solicitor. Yours sincerely, Sarah G——"

The ideal contributor can be relied on for brightness and originality, for giving the editor as little trouble as possible, for knowing the paper as well as the editor himself, for sending an article of the right length at the right moment. He is not discouraged if an article comes back, because he has learned by experience that often the last reason in the world why an article is returned is that the article is bad. He knows that a good article may be returned for a dozen reasons. The editor may have arranged for one on the same lines, or may have published one recently which the contributor did not notice; the article may clash with some other article that has been or is to be published; the treatment of the particular subject may be uncongenial to the editor; the editor's desk may be so congested with manuscripts that he has no right to keep the article until he can consider it. Even ideal contributors may be disappointed for reasons such as these, and the unideal contributor, of course, runs a hundred other risks of disappointment which he never seems to realise.

Contributors who Never Contribute. The writer who never gets into the papers has generally an explanation of his own; probably there is a plot against him among the editors. But it is really not the case that all the editors in England are taking great pains, at the risk of ruining their papers, to deprive the reading public of the intellectual output of Mr. Richard Tomkins or of Miss Susannah Jones. It is conceivable that there are other reasons. Their articles are probably far too long, or they may be unintelligible, or written on both sides of the paper, or underlined and crossed out in such a way that nobody can read them, or about things which interest nobody, or on subjects of which everybody is tired, or summer articles in winter, or winter articles in summer, or abstruse discussions of theology, or long exordiums on philosophy, or abusive articles on public men, or hysterical articles on private matters, or articles full of glaring errors, or essays as dry as dust, or politics opposed to the paper's own, or articles with libels in every line, or attacks on the paper's contemporaries, or insidious cultivating of private

interests, or articles likely to be mischievous in the money market.

It would be possible to go on at any length giving reasons why papers do not publish articles. A glance at an editor's "rejected" box would be an effective lesson to amateur journalists who write whenever they can instead of only when they must, and allow their lives to be soured by the disappointments they bring upon themselves.

An Editor's Rejected Box. Let us take a peep into the rejected box of the editor of what are probably the most coveted columns in English journalism. They afford a journalist the most powerful pulpit that he can find in England, and if the reader will remember this it will help him to understand the editor's point of view in sending back the dozen articles we have picked out for notice. We set out the authors' headings of the articles, along with an explanation why they were not accepted.

Our Dreadful Musical Likes and Dislikes. Not published for several reasons. 1. The style did not suit the paper. 2. The manuscript resembled a map of Europe with its mass of blots and corrections. 3. The article was twice as long as it should have been had it been twice as good as it was. 4. It was accompanied by this impertinent letter: "Dear Sir, If you are not brave enough to use the enclosed, will you kindly fold it twice, returning it in the enclosed cover? If it is to be used, will you please settle terms with me before it is put in type?"

Behind the Walls of a Lunatic Asylum. The writer declared it to be the most thrilling narrative ever seen on the subject, and wrote: "Please see that Mr. —— sees it. It is good enough for the Christmas number. I expect a cheque for it. If not accepted, return. Tell Mr. —— I expect £20 for it."

The Present-day Snob. In sending the first of a series of six articles the writer, an example of the intolerable "smart" contributor, said: "I am desirous of seeking fame and, incidentally, cash, by asking you to read the enclosed article, the first of a series of six. If, however, the article is too feeble, and makes you feel at all peevish, be good enough to return it in the accompanying stamped envelope, and I will use it for pipe-lights."

Opportunities in the East. Extract from author's letter: "I admit the writing is feeble, but perhaps, with many additions known best to an editor, you may find an odd corner in the least important of your publications. It is very much in season, and will do you good if it appears."

The Gate of Empire. Not published in spite of the fact that a friend of the author wrote to the editor: "Will you be good enough to say when an article entitled 'The Gate of Empire' is to appear, as I intend securing several copies of the paper?"

Vegetarians and Fruitarians v. Meat Eaters. Extract from author's letter: "Would you be willing to take an essay on this subject? It would probably occupy eight or ten columns."

Santa Claus. Extract from author's letter: "Perhaps the enclosed manuscript may be of use when you have nothing suitable at hand."

No Title. Extract from author's letter: "I enclose an article for your Thursday issue. If you would like it re-written plainer I will do it."

A Short Story. Extract from author's letter: "Mr. —— of the —— ——, after reading the enclosed story, advised me to send it to you. I have for some time been trying to get a personal introduction to you, which I still hope to do, although I have so far been unsuccessful."

The Wild and Woolly West. Extract from author's letter: "You may blue pencil it as you see fit. I am after dollars, not glory. Of course, the stuff is original and exclusive. If you think it is 'fishy' any of the gang round the Cecil will O.K. it.

Problems on Juggernaut and the Great World's Misery. Seven columns from a rector's wife.

Tariff Reform. Extract from author's letter: "I beg to enclose an article. You will perceive I have not even troubled to correct or alter same. I have always written under the *nom de plume* 'Vincit veritas,' as I believe truth always conquers, and can write more articles on the same subject."

Women in Journalism. The sensible contributor does not call, as a woman called at the office of the Daily Mail, to see "if there is any personal reason why articles are not accepted." He goes on writing until his articles are accepted, and until he has made his connection so secure that all anxiety concerning his manuscript comes to an end.

Nothing has been said in these articles as to journalism for women. It is true that there are certain departments of work in which women are useful, and, indeed, necessary, as contributors to magazines, and, more rarely, to newspapers. But the woman journalist is not usually a success. The conditions of journalism are not for her, and women are wise in confining themselves, if they write at all, to work involving none of the rush and anxiety of ordinary journalism. There are regular departments such as dress, health, cookery, and domestic interests generally which afford scope for the woman who has a stock of useful knowledge and a gifted pen. But this is not journalism proper, and from a professional point of view the prospect for women journalists is not particularly bright. Obviously, however, all that has been said of journalism applies to journalists apart from sex.

The Journalist's Income. The free-lance who succeeds in journalism should be perfectly happy in his work. He may make any sort of income within reason. It is not surprising to hear of men who make £1,000 a year, though it is common enough to meet men who make the barest living. It is a highly creditable thing if a man can sit at home and make £500 a year by his pen, and, with some capacity for organisation and the instinct of journalism within him, this should not be very difficult. It is a good plan to have a regular piece of work, such as two days a week in an office or a daily or weekly column of notes, and this security of an income sufficient to meet the bare needs of existence saves the free-lance from much anxiety. He should write only for papers that pay regularly, and should cultivate connections upon which he can rely.

With half a dozen papers to write for, a well-equipped library to work in, and good health, the journalist with a brain is the happiest man in the world. He is monarch of all he surveys, and would not change places with a king.

Continued

GROWING TREES FOR TIMBER

Shade-bearers and Light-demanders. Pure and Mixed Woods. Sowing and Planting. Species of Trees. Sylvicultural Systems. Forest Management

By HAROLD C. LONG

THE systems of *sylviculture*, like those of ordinary farming, depend, to a larger extent than is often allowed, on the position and locality of the area concerned, and also on the species of trees which are selected. It must be clearly understood that the habits of various trees differ very materially, and in selecting a system it is necessary to consider especially the soil, climate, aspect, and species of trees. Let us now deal with and define some of the commoner terms employed in sylviculture.

When the leaves of a tree fall at a certain time of the year, leaving it bare, as in common oak, elm, and plane, that tree is said to be *deciduous*. If a tree retains leaves throughout the year, such as the pine, it is an *evergreen*. Not that the leaves or needles of pines do not fall; they do, but they are so continuously renewed that such trees always bear leaves.

Certain species of trees—*e.g.*, the yew, beech, spruce, and silver fir—flourish under more or less heavy shade in early youth, not requiring full conditions of light in order to live and produce good timber—that is, they will "bear shade," and hence they are termed *shade-bearers*. Other trees—*e.g.*, the oak, larch, and Scots pine—require a great deal of light, not only to enable them to produce good timber, but in order to sustain life. Such species are termed *light-demanders*. In America shade-bearing and light-demanding species are respectively termed *tolerant* and *intolerant* of shade.

Pure and Mixed Woods. When a wood or forest consists practically of one species of timber tree it is said to be a *pure* wood, while if several species compose a crop a *mixed* wood is the result. It may, perhaps, be said that pure woods are more frequently composed of shade-bearing than of light-demanding species. The latter generally occur in mixed woods, as when alone they neither preserve the soil sufficiently nor produce the best quality of timber. Oak and larch, for instance, are grown to greater profit when associated with beech and silver fir, though they are also capable of forming pure woods. Trees which bear cones, and which in general do not shed their leaves or needles, such as Scots pine and spruce, are *coniferous* trees; those like the oak, lime, and ash are *broad-leaved* species. Those species of trees, whether coniferous or otherwise, which are most suitable for forming pure woods are termed *ruling* species—for example, silver fir, beech, Scots pine, oak, spruce, and larch; those trees, on the other hand, generally found in mixed woods, where they do not predominate numerically, are *subordinate* or *dependent* species, as ash, lime, Norway maple, and sycamore.

Rate of Growth. The various species of trees differ considerably in their rate of height growth, and this fact is of great importance, especially during the youth of the trees. On soil specially suited to larch this species would grow faster than spruce, practically until mature, whereas on soil less suited to larch the spruce would overtake it in height growth in about 25 years or less, with disastrous results to the larch. Again, in a mixture of oak and beech, in a locality suited to the former it would grow ahead of the beech for 50 years or more; where the locality proved less favourable to the oak, it might be caught up in 20 years, and suppressed. In such a mixture, therefore, the oak is given a start, the beech being introduced when the oak has attained 40 years of age or more. We see, then, that in mixing species an important factor, *height growth*, must be considered. *Diameter growth* is, generally speaking, fairly proportionate to height growth, but depends very largely on space allowed per tree. If space be too limited, or, in other words, if the wood be overcrowded, the diameter growth is decreased, while the height growth is increased; too free a position increases diameter growth at the cost of height growth. A judicious space allowance permits a correct combination of height and diameter growth, the result being the best yield in *volume growth*. Regular and slow growth produces the best timber. A close canopy must always be maintained if first-class timber be required, and this means that trees must stand close together, but not so close that injury results.

Sowing. In the forest nursery the principles involved in sowing the seed are somewhat the same as in farm practice—the larger the seeds the deeper they should be planted; the majority of seeds are most suitably sown in drills, although the smaller light seeds (elm, birch) are sown broadcast. The soil should be deep and friable, and as free as possible from stones. A cleaning crop, such as turnips, may profitably be taken in the first year, after which the land may be used for raising seedlings, and for transplanting these for three or four years. Drills for sowing may be prepared with a common hoe, or by a board with attached mouldings, which are impressed on the seed-bed. After the seed is sown the soil is raked over with an ordinary rake. Light rolling makes the bed moderately firm. The hand is used for broadcast sowing, and for placing large seeds, like acorns; but a special seed horn is useful for smaller seeds. Broadcast sowing absorbs far

Photo, Wm. M. Watt

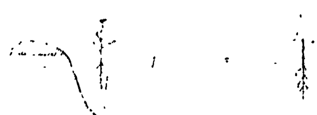
1. NURSERY SHOWING LARCH SEEDLINGS AND TRANSPLANTED LARCH

more seed than drill sowing, while it also needs a more carefully prepared seed bed. The usual time of sowing conifer seeds is almost invariably in spring, but broad-leaved species are sown from November to March, when temperature and the condition of the soil admit.

In the forest, partial sowing is often resorted to—that is, small patches or strips are prepared and sown, or large seeds are dibbled.

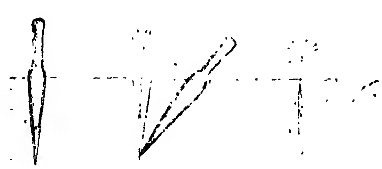
All seeds used should be fresh, ripe, of good size and weight, and have a good germinating capacity. The quantity of seed sown depends largely on the local conditions, on the quality of the seed, and on the rate of growth of the species.

Planting. Seedlings are pricked out in the nursery and transplanted, only once or it may be several times over [1]. The utmost care should be exercised in taking up and transplanting either seedlings or larger and older plants. Fairly small plants are more easily manipulated, and are less expensive than larger ones for planting in the forest. Nursery stock, when planted out in the plantation, should be healthy, shapely, well developed, and have good root systems, the roots being more "bushy" than "tap-like." It is of the utmost importance that no stock in any way affected by disease be used. The best age is perhaps four years, but seedlings, or plants from the seed-bed, are also occasionally suitable for planting out, transplants being used to replace any failures as necessary. Small plants are best removed with soil attached. In correct sylvicultural practice planting is usually done in *pits*, that is, holes dug expressly and of such a size that the roots may be arranged as naturally as possible [2]. In no case should the roots be in an unnatural, cramped position [3]. The *pits* are frequently dug during the winter before planting, the final insertion of the plants taking place in spring, after the soil has become mellowed. Loose soil is sprinkled over the roots when these have been *spread*, the soil gradually burying the roots. The whole is finally trampled firm. *Pit planting* is the most expensive method of establishing plantations. *Ball planting*, using small plants with the soil firmly attached as removed from the nursery bed by a circular or semicircular spade, is especially adapted to loose soils and for unfavourable localities generally. With small balls the expense of planting is not great. In some cases *peg planting* is resorted to [4], this method resembling ordinary dibbling. It



2. GOOD PLANTING

3. BAD PLANTING



4. PEG PLANTING

is only suitable for small plants, and is then cheap. Plants may be thus inserted fairly naturally, and if roots are long, they may be somewhat curtailed. *Notch-planting* is largely recommended on account of its cheapness at the outset. It may be done in several ways: (1) By making a cut in the sod to form an L or a T. The corners of the sod are raised and the plant inserted and trodden in. This system is seldom to be recommended, the roots being almost always twisted or buried too deeply, with serious results. (2) By using the "wedge" spade, in which case a wedge-shaped opening is made in the soil, and by movement to and fro of the spade a vertical face is obtained on one side of the "notch." The plant is placed at this side, the spade again inserted two or three inches back on the other side, and a fresh cut of soil pressed against the plant, closing the notch.

Time, Density, and Cost of Planting. Wounding the plants in the course of planting should be carefully avoided, as wounds may afford entry for fungoid diseases and insect pests, and are responsible for much trouble.

Autumn and spring are the best times for planting—just when growth is over before winter, or just before growth begins in spring. It is desirable to get a good cover in six or seven years, and planting must be dense enough to effect this. *Density* of planting will depend on the species, size of plants, and on the class of timber or other wood it is desired to raise. Three to four feet for Scots pine, 4 ft. to 4½ ft. for larch, and about 4 ft. for oak may be taken as average distances for average plants. At 3 ft. apart each way, 4,840 plants are required per acre. The cost of planting varies according to the number of plants per acre and the method of planting. It may be from £3 to £6 per acre.

5. WINDFALLS IN A SPRUCE WOOD

Species of Trees. Of timber trees of chief importance may be mentioned, among *broad-leaved* species, the oak, beech, ash, birch, hornbeam, alder, elm, lime, poplar, and among *conifers*, the Scots pine, larch, silver fir, Douglas fir, Weymouth pine, and Corsican pine. Of these, the most important are oak, larch, beech, silver fir, Scots pine, and spruce, followed by the ash, birch, and alder. At this juncture we shall discuss briefly the chief points of some of these trees.

Oak. For our present purpose two species of oak, *Quercus pedunculata* and *Q. sessiliflora*, may be considered together. The oak is a strong light-demander, and withstands storms better than almost any other tree. It may live to a great age, grows fairly rapidly in youth, requires a fertile, deep soil (being decidedly exacting in this respect), and occurs both in pure and mixed woods. It is perhaps seen at its best when grown in mixed woods with beech, which may most advantageously be introduced as the oak begins to thin out. As it reproduces with ease by coppice shoots it is admirably suited for the *simple coppice* system and for *coppice with standards*, while with *high forest* systems it does exceedingly well. When grown for bark for tanning purposes, the coppice with standards system is usual. [For qualities and uses of the various timbers see MATERIALS AND STRUCTURES, page 51.]

Scots Pine. Scots pine (*Pinus sylvestris*) is one of the most important of coniferous trees, large quantities of the timber being imported into this country as red Baltic pine or Baltic red-wood. It is hardy, storm-firm, withstands frost and drought well, and prefers a deep, porous soil, but is very adaptable in this respect, a moderate sandy soil suiting it excellently. Like the oak, it is strongly light-demanding, and it grows quickly all through life until mature, attaining upwards of 100 ft. in height. Although extensively forming pure woods, it is suited to form mixed woods with beech and silver fir, and is adapted for growth under most sylvicultural conditions.

Beech. Beech (*Fagus sylvatica*) is one of the first of shade-bearing or tolerant trees, and is eminently suitable for growing in pure high forest, though excellent for mixed woods, while for underplanting pure high forest of oak, ash, etc., it stands unrivalled. In mixed woods it is the chief species, and Scots pine, oak, ash, larch are at their best when mixed with beech. It needs open, good soil, grows slowly at first, but faster after about 30 years of age, is somewhat damaged by late frosts when young, and its volume growth exceeds that of any native broad-leaved species.

Ash. Ash (*Fraxinus excelsior*) is a useful timber tree, being next to the oak in its light requirements, but it is especially liable to fork or divide its stem. Ash coppices well, and takes a firm hold of the soil, which requires to be moist and porous, but it is apt to suffer from late frosts and drought. It is most suitable for admixture with beech, and occurs in high forest; it reaches maturity about the seventieth year, and ought to be felled shortly thereafter.

Larch. Well-grown larch (*Larix Europaea*) yields a very durable timber, which is perhaps more valuable than any coniferous timber in Great Britain. It demands light more than any other British timber tree, is very stormfirm, a quick grower, requires a moderately deep porous soil, and is very hardy as regards cold. It may often be underplanted with beech or silver fir when about 30 years old, but is quite unsuited to pure forest. It is grown in high forest, and can be employed as a shelter wood for tender species—such as beech. Especially within recent years larch has suffered severely from the attacks of a fungus, to be described later.

Spruce. The striking conifer spruce (*Picea excelsa*), with its long leading shoot and conical shape, is a tree of the mountains. Like the beech and silver fir, it is able to endure shade. Spruce is hardy, but requires a moist locality; it is not found in dry soils, but a deep soil is unnecessary. The spruce is easily uprooted by gales [5]. When grown in well-stocked woods, it forms a first-class timber, which is soft and light, being known in the trade as *Baltic white pine*, Scots pine being the *Baltic redwood*. Being one of the chief shade-bearing species, it is well suited for pure woods in high forest, but is not so useful for underplanting as beech.

Silver Fir. Silver fir (*Abies pectinata*) may be termed the chief shade-bearer among our coniferous trees. It is liable to suffer from frost in youth; grows but slowly in early life, later on, however, forging ahead very rapidly, its volume increment being second to none of our common forest trees; and it is at its best on a deep, somewhat firm and moist soil. Like the spruce and beech, the silver fir is peculiarly a pure forest type of tree, maintaining a close cover until late in life, although frequently occurring in mixed woods. With beech silver fir forms an excellent stock. It may be usefully employed for underplanting Scots pine or oak, when it is best introduced as these are about to thin out.

6. MATURE BEECH WOOD NORMANDY ORIGINAL NATURAL REGENERATION

Douglas Fir. Douglas fir (*Pseudotsuga Douglasii*) is a recently introduced species from the North American continent, where it is known as the *red fir*. Owing to the fact that it grows rapidly, attains a great size and forms a first-rate timber, it is likely to prove a very valuable introduction to this country. It is fairly hardy, but when exposed to the prevailing wind is apt to lose its leading shoot. It can be grown in pure woods.

Sylvicultural Systems. Under the systems of sylviculture we shall consider both natural and artificial regeneration, the first being undertaken by Nature, and the second by man's interference and direction. The choice of the system to be followed depends on locality, species, economic grounds, and a variety of conditions. The systems which generally prevail are (1) Clear-cutting in High Forest, (2) Regeneration under a Shelter-wood, (3) Regeneration by Coppice, and (4) High Forest with Standards.

Under the system of *Clear-Cutting in High Forest* an area is directly sown, or planted, or sown naturally with seed from an adjacent wood, the crop completely cut when mature, and the area resown or replanted. The produce is usually of a good class, the most unfavourable point being that an interval occurs when the ground is bare. *Regeneration under a shelter-wood* may be carried out in one of several ways.

(*a*) In one case, the existing wood is thinned, and a new crop allowed to come up naturally from seed under shelter of the parent trees; or regeneration is effected artificially by direct sowing or planting under the old trees, which are cut over when the new crop is established [6 and 7]. (*b*) In a modification of (*a*) the wood is treated in *groups*, instead of in its entirety. (*c*) Another modification is one in which trees, or groups of trees, or definitely arranged blocks, are *selected* for cutting and regenerating in turn, so that there is always some part under treatment. The shelter-wood is suitable for shade-bearing species.

Regeneration by Coppice. In the case of broad-leaved species, *Regeneration by Coppice* is very frequently effected by shoots which spring from the stem, roots, or stool, ordinary coppice being that resulting from stools of trees which have been cut over close to the ground. Growth is rapid under this natural system of regeneration, and cutting takes place at from one to two years with osiers, at 20 years or more for oak (grown largely for bark), or over 30 years in the case of the alder. A combination of this system with high forests results in *Coppice with Standards*, in which some of the best trees are left and allowed to reach maturity as in high forest, the simple coppice forming an underwood.

In the *High Forest with Standards* system a few of the best trees are left at the time of cutting over high forest that they may mature more fully, and in the following crop they exist as standards. Under certain conditions, especially with light - demanding species, woods begin to thin out at a certain age, when a second crop may be introduced to protect the soil. In such a case there will be two high forest woods of different age classes growing together. This is termed *Two-storeyed High Forest.* This again may vary in such a way that the introduced crop takes the form of a scrub or coppice, when the system is *High Forest with Soil Protection Wood.*

7. NATURAL REGENERATION OF BEECH UNDER A SHELTER WOOD

Natural regeneration is cheaper than the artificial method. When a wood or forest is to be established on new ground, this is best done by planting the area with young plants raised in a nursery.

Forest Management. Coarse, knotty timber is largely due to unrestricted development of side branches, due in its turn to absence of competition between individual trees. That is, instead of close planting (the correct procedure, which yields fine, clean timber, the boles being long, straight, and of good shape), the trees have been planted, or allowed to grow too widely apart. From the time an area is planted, a close canopy should be kept, but all dead, suppressed, diseased, and dying individuals should be *thinned* or weeded out. Sufficient space must be allowed for right development, consistent with maintaining good cover for the soil. Under such close canopy, *self-pruning* takes place owing to pressure of individual trees on one another, the lower branches dying off as the crowns press upwards to the light.

How Trees Suppress Each Other. Thinning also takes place naturally in this way, the more vigorous members suppressing their weaker neighbours. In thinning it is usual to remove the very worst trees, such as dead, dying, and diseased ones, together with the smaller and weaker individuals. All the best are left to attain maturity, or at least as many as may safely be left. Close growth means slow growth—that is, good quality timber.

Dead wood in a forest may be taken as a healthy indication, provided the trees are not found dying in patches throughout the wood.

A newer method of thinning departs from the ordinary principles in two ways: (1) it does not countenance the removal of weak and partially suppressed trees; (2) it is not afraid to attack the dominant class, or even to interrupt the canopy temporarily for the removal of objectionable trees, the idea being to benefit the remainder. By this method sound and vigorous trees are in some cases removed; the remaining trees are encouraged to increased production, while more timber is obtained from the increasingly severe cuttings than is general from the usual process of thinning. No more wood should be removed from a forest in a given time than it is able to produce in that time.

Felling. The final felling of the mature crop should preferably take place when snow is on the ground, and timber is best removed in frosty weather, when the ground is hard.

In the case of natural regeneration by seed, the later thinnings may take the form of fellings, the object of the first felling being to prepare the seed-bed where there is too much humus, to strengthen the trees and give light for the production of seed; a later felling—termed the *seed felling*—by which trees not required for seed or shelter are removed; and, lastly, the felling of the remaining trees when they have done their duty in seeding the area. Final felling of timber usually does not take place until the trees have a fresh crop established under them.

Figs. 2—7 are taken from Dr. Schlich's "Manual of Forestry" (Bradbury Agnew & Co., Ltd.).

Continued

HOW TO FEED & CLOTHE CHILDREN

Infant Feeding. The Importance of Pure Milk. Hygienic Underwear. A Child's Bath. Exercise. The Nursery

By Dr. A. T. SCHOFIELD

IN all ranks of life the young mother approaches her double task in a state of pitiable ignorance, and, unless she is gifted with more than the average common-sense, the result is more or less lamentable. The young life is either sacrificed outright, or the child is stunted, ill-developed, and bears all through its life the painful result of the maternal ignorance.

The Making of a Healthy Child. Birth is really the second stage of the child's existence, and for many reasons it is important to recognise this fact. The first stage of life is, however, to a large extent a passive one. The child's wants are at this period so perfectly met in every way by the mother that the whole complicated machinery of the body is idle. It neither breathes, digests, nor thinks. The most important condition which at this period determines the child's health and growth is the health of its mother. No woman should risk becoming a mother unless in good health during the time.

The conditions mentioned being favourable, and the parents of average size, the baby will measure from 20 to 21 in. long, and will weigh nearly 7 lb. (a weight now frequently exceeded), part of which weight will soon be lost, but made up again by the end of the first week.

A baby requires little food at first, *no butter or sugar*, and no laxative. It should in every case be put to the mother's breast as soon as possible, and nursed, at any rate for the first three months, even if it be impossible to nurse it longer.

The Composition of Milk. The question of infants' food is so all-important to the race that it will be well to go into the matter in some detail. Milk is a fluid consisting of two sorts of cells (fat cells and living white corpuscles suspended in serum); or it may be regarded as water in which is dissolved milk-sugar, serum, albumen, and casein. Some of the cells are believed to retain their vitality in the milk if it is not boiled. Milk kept for a time tends to separate into serum and solids, just as blood clots when drawn out of the body. The boiling of milk coagulates the serum albumen (as a skin), but not the casein or curd. Milk is not merely a secretion from the cells of the mother, but consists partly of the cells themselves, which are an actual part of her, and has thus been supposed by some to have a vital influence on the child. Mother's milk contains also any drugs, or alcohol, or other special fluids that may be circulating in the mother's blood; and Professor Kanthanck has pointed out that if the mother be immune from any infectious disease owing to an antitoxin, her milk will render the baby immune from the same disease, a virtue that disappears if the milk be boiled.

The importance of breast-feeding is unquestioned; 500 infants in 1,000 are known to die in some localities where the child is never nursed, and impure cows' milk is given. The lowest infant death-rate is in Sweden and Norway (10 per cent.), where they are always breast fed; but in England it is 42 per cent. In the Siege of Paris the infant mortality, instead of being increased, was reduced 4 per cent. by compulsory breast-feeding.

How to Treat Milk. Where the child is not nursed, diluted cows' milk is given, or the mother's milk and cows' milk can both be used.

Humanised milk is cows' milk made to resemble mothers' milk. This is done in various ways. The following are two good recipes:

Sterilised cows' milk, eight tablespoonfuls; cream, two teaspoonfuls; sugar of milk, half a teaspoonful; boiled water, two tablespoonfuls.

Sterilised cows' milk, eight tablespoonfuls; cream, six tablespoonfuls; water, twenty tablespoonfuls; sugar of milk, six teaspoonfuls; lime-water, two tablespoonfuls.

Humanised milk can now be bought sterilised and ready for use in sealed feeding bottles that only require fitting with a teat to be taken directly by the infant.

When humanised milk is not given, pasteurised (sterilised) milk should be used. The old idea was to boil the milk. This was necessitated by the facility with which the milk receives and multiplies bacteria. Sterilised milk is superior to boiled milk in several ways:

(1) Because the process can be conducted in the very bottle from which the baby drinks.

(2) Because the bottles of milk are heated in a water bath, and only raised to 180° because the boiling point of milk is so much higher than water; whereas if boiled it is raised, of course, to 212° or more.

(3) The curd is not hardened, but disintegrated and flocculent when it reaches the stomach.

(4) No skin (albumen) forms on the surface, and therefore this valuable ingredient is retained in the milk.

(5) All germs are destroyed as at 212°.

Mistakes About Milk. The sterilisation of milk has now reached such a pitch, and is so universal, that, curious to say, it has almost become a danger.

As knowledge spreads among mothers, milk is increasingly boiled at home before use. If it be sterilised unknown to the consumer before it arrives, and then boiled by the purchaser the result is an impoverished food, and anæmia and scurvy not infrequently follow.

Condensed milk may be another and much more serious evil. First the quality varies so much. In the Milkmaid and other good brands, the fat will average 11·5 per cent.; in common

brands 2 per cent. On the cover of the tin of the cheaper brands, in small letters, the word "separated" is found, signifying that what is condensed is "separated" milk worth ½d. or 1d. per quart, from which every particle of fat or cream has been removed, and on which the child can only starve. This word is often overlooked, and the parent wonders why the child pines.

Another evil is that the right strength is not given. Good condensed milk should be added to the water in this proportion: Before one month, $\frac{1}{10}$; from one month to five months, $\frac{1}{30}$ to $\frac{1}{10}$.

A third mistake is that due distinction is not made between condensed milk with and without added sugar. It is best *without*, but then it will only keep good for a day or two when the tin is opened, whereas with 30 per cent. of added sugar, which does not agree with the child, and tends to produce all sorts of skin eruptions, it does not go bad.

It is said that 100,000 infants die needlessly every year. Picture this enormous waste of human life, and then let us remember that it is principally (four-fifths) due to improper food.

Not until a child is six months old can it live on vegetable food; till then it is an animal feeder, and consumes, *in proportion to its weight*, twice as much animal food as a man, averaging daily 30 grains per pound weight as compared with 15 grains per pound in an adult.

Infant Nursing. In nursing a child the mother should lead a healthy, regular life, with plenty of nourishing food. Stimulants are not required, and it is important to remember this, as the habit of giving young mothers stout and strong beer, to say nothing of spirits, lays not only a disastrous foundation for the subsequent married life, but for the baby's constitution as well. The best milk maker is milk; the next best, perhaps, is cocoa. Nothing that tastes very strongly, such as onions, should be eaten, and all rich food should be avoided.

With regard to the times of feeding the child, it should, in the first place, be fed regularly, and not always when it cries. This is of the utmost importance to both parent and child. For the first three months every two hours in the daytime, and every four at night, is quite enough; and after then, if the child be strong and well, every three hours in the day and every six hours at night.

The amount of milk that is yielded by a good nurse is about four tablespoonfuls in each breast every two hours. At first a child exhausts one breast only, later on, both. A child should, as a rule, be allowed to suck until it shows it has had enough. A child would then, if under three months, drink about a pint a day, and about a pint and a half over this age.

When a child has sucked, its mouth should always be washed to prevent the formation of thrush, a small white fungus that grows about the tongue and sides of the mouth. The nipples should also be well washed, and can be hardened, if needed, by sponging with brandy. Of course, nursing is a great tie to a mother, who must be in at the regular hours if she would do justice to her child; for if the food be given at too long intervals, the child takes it too quickly, and all sorts of dangerous stomach disturbances are caused.

Occasionally, through worry or overwork, mother's milk is too poor; it may become scanty and insufficient, or some sudden shock or other cause may stop it altogether. In these cases it is better partly to suckle a child than not at all. There is absolutely no foundation for the popular idea that it is wrong to give cows' milk and the mother's milk together. If the milk be scanty, a better plan than giving the breast in the day and the bottle at night is to give them alternately.

Feeding Bottles. Setting aside wet-nurses as being too difficult to obtain readily when wanted, the question is, if the natural supply fails, how should the infant be fed? In the first place, the bottle itself should always be kept perfectly clean. A boat-shaped bottle, with a calf's teat, is easily kept clean, but until lately it has been completely driven out of the field by other shapes. The bottle with the long indiarubber tube can be placed in almost any position without being upset, and hence is so popular because the mother can leave the child to suck by itself. This is not a good plan, for not only are the bottle and tube always dirty, but too often it leads to the child gulping down quantities of air through sucking at the bottle when empty. The best course is to use the bottle (fitted with a teat) in which the milk has been sterilised. The milk, not necessarily obtained from the same cow, should be perfectly fresh and sweet. It should not be kept in the bed-room, and the jug or bottle should be scalded and made perfectly clean. The least dirt or drop of sour milk will soon turn a whole quart. The milk should be sterilised by the bottle being placed in a saucepan of water until the water boils. The proportion of *boiled* water added should be one-half, and if the milk be rich, a little more at first; a small quantity of white (preferably milk) sugar may be added. The bottle should be given at blood-heat.

How Milk Should be Warmed. It is very dangerous to keep the milk warm all night by a small light, as, in this case, it constantly turns sour. It should be kept quite cold, and warmed only when needed. Nothing whatever in the way of food but milk-and-water should be given to a healthy child. After the first three months only one-third of water is needed to two-thirds of milk. Should the milk disagree with the child, and heavy curds be brought up, then a little lime-water may be added, which may be increased, if necessary, until nothing but lime-water (which is quite harmless) instead of water is added. Sometimes, when the milk is "on the turn," a pinch of bicarbonate of soda will put it right, but it is better not to use it. If it be still found to be too heavy, as is shown by curds being brought up or passed, some change must be made. Condensed milk is lighter than cows' milk, but generally contains such a quantity of sugar that it often produces

skin eruptions, and makes the child fat rather than strong, although with some it agrees fairly well. Barley-water (two teaspoonfuls of pearl barley to a pint of water, simmered slowly to three-quarters of a pint, and strained) and cream is very light. The humanised milk prepared by the great London dairies is highly to be recommended, and will nearly always agree with the baby.

Prepared Foods. If the child still appears starved and hungry, and needs something more, there are some digested foods, prepared by Allen & Hanbury, Mellin, and others, which can be safely tried. Ridge's Food, biscuits of any sort, and other milk foods, must *not* be given till after the child is nearly six months old, since before that age it is absolutely incapable of digesting any sort of flour.

It is a great mistake to feed the baby too frequently. After the first six months the child will go at night, from eleven to five, without food.

If possible, a child should not be weaned in summer, but about the sixth month the amount of nursing should be decreased. After the first teeth are well through, about the seventh or eighth month, the child may be weaned. It is a great mistake for mothers, for any reason, to continue suckling as long as fifteen months.

After the sixth month the child can take Ridge's Food and plain flour foods, rusk, and biscuit. Rusks and tops-and-bottoms are very good at first, but bread should not be given until the child is well accustomed to the finer food. At eight or nine months the child can begin to take a little broth or beef-tea. Milk should always be the child's mainstay for the first few years of its life. Sugar is good for children *with* their meals, and after one year a little meat may be given once a day. Oatmeal is very fattening, although rather heating. The diet should be light and nourishing. Light-boiled eggs are very suitable, and there is no objection to a little *ripe* fruit.

A Child's Menu. The great danger a careful mother is apt to fall into when her child is between six months and two years old is giving it too much farinaceous and too little animal food. We are apt to think flour foods can take the place of milk; but, though they present somewhat the same appearance, they are in reality very different from it. Milk is truly animal food, and contains plenty of material for building up the child's body. Now, a child requires, seeing it is growing rapidly, far more animal food in proportion to its size than a man, and this is most conveniently given in the form of milk. Any vegetarians who read this must clearly understand that if they had excluded animal food from birth they would not be alive to-day, for we are all born animal feeders. At eight or nine months a baby may have a little beef-tea and, at fifteen months, a little under-done meat scraped into fine pulp and moistened with beef-tea or plain gravy.

A suitable dietary for a child of two years old is a breakfast of bread-and-milk, porridge-and-milk, or an egg; a dinner of meat, fish, or chicken, with a little mashed potato and a light milk or egg pudding; a tea of bread-and-butter and milk, with a little treacle; and for supper, bread-and-milk. The child should continue to take at least $1\frac{1}{2}$ pints of milk in the day.

Children's Clothing. There is no doubt that there is room for a greater reform in infant clothing. As much as is possible of a baby's clothing should be of flannel of a fine and non-irritating quality. An elastic woollen binder round the body is very useful during the first few months. This binder used to be sewn round the baby's body very tightly, and was made of rigid and unyielding cotton cloth. One result was that babies continually suffered from jaundice, and there can be no doubt that when the body is so soft a very tight binder must seriously interfere with the action of the liver. The ideal binder should be made of some webbing which will give a little. Beyond this, the child needs nothing indoors but the cambric, or fine linen shirt, the flannel gown, and, if needed, a warm shawl.

Napkins should only be worn when the child is being carried about, at other times its legs should be quite free; no waterproof should be worn over them. For out-of-doors an extra soft woollen gown, and on the head a soft light woollen hood. The child's face should always be uncovered, and no thick veil or handkerchief ever allowed. All clothes should be made to open in the front.

At night the child should be all in flannel. A baby should wear soft woollen socks; no stiff boots or shoes should be allowed, excepting when absolutely needed out-of-doors.

At the age of four months the child's clothes should be shorter; but even before they should never be of the absurd fashionable length. The change, however, should not be made in wintry weather. The short clothes should also be of flannel, the sleeves loose and long, the neck high - not tight. The legs should now be protected with woollen gaiters, and no infant should be allowed to go about with bare legs and arms.

The Nursery. Infants require an immense amount of light and air. Fresh air and sunshine not only invigorate and promote the growth of their young bodies, but they also kill and destroy all germs of disease. Light is a great factor in forming good blood. Infants cannot thrive, even with every care, in a dull and sunless room; while, on the other hand, they do grow wonderfully when they have plenty of light and air, though they may be often grossly neglected in other ways. The nursery should always be the brightest room in the house. It should be on the first floor, or higher, and should be sunny; it should have a fireplace and plenty of access for fresh air at night. The room should be as bare as possible, and scrupulously clean.

Young infants should not be taken out-of-doors during the first month; and when it is for the first time, a fine warm day should be chosen. If the temperature out-of-doors is 60° F., the baby may begin to go out on the fifteenth day. Of course, if it is winter-time, it should not go out until it is

older. Long exercise in a perambulator soon chills a very young child: the nurse's arms are far better, and the continual exercise for the child as she walks about is very good for it. A child should be carried on the right and left arm alternately.

Older children should be kept out-of-doors as much as possible, and, well wrapped up, they can endure most weathers, excepting east winds and rain. In summer, a child should be kept indoors in the middle of the day, and taken out morning and evening. The temperature of the nursery bed-room should never fall below 55° F. in winter, or be above 65° F. in summer. The nursery may range from 65° F. to 70° F.

With regard to cleanliness, the first step is at birth, when the child's eyes should be carefully bathed. If this be not systematically done, and any poison has entered during birth, the eyes soon swell and inflame, and a child often goes blind during the first week of its life. For children to be "born blind" is the rarest of events, but for them to be blind from birth is very common, and nearly always is due to nothing but want of cleanliness

Baths. All infants should be bathed at first in warm water, about 95° F., gradually reduced to 70° F. by the end of the first month. The water should be soft—rain water is best—and curd soap should be used: a soft flannel for the soap, and, when it can be procured, a Turkey sponge for the water. Very little soap should be used to a baby's skin, as it destroys the secretion of the oil glands and renders the body liable to cold. The baby should be bathed before his breakfast, and it is most important that the nursery door be locked during the first few baths.

After the first fortnight he can be put in the bath instead of being washed on the knee. He should not remain in it long, and be quickly dried with a warm, soft towel, and then rubbed all over with the warm hand, and dressed.

Cold baths should not, as a rule, be given to infants till they are eighteen months old, at any rate. The best way, at first, is to put the children into warm baths, and finish up by a sponging with cold water. As they get used to this, they can stand in warm water, and be sponged more freely with cold, and in hot weather the bath can be taken quite cold.

The child should never be allowed to get cool before the morning bath, but should be taken straight to its bath out of bed. Great care should be taken thoroughly to dry children after their bath, or sores and chaps soon appear in the folds of the skin. When quite dry, the part liable to friction can be powdered. It is important, therefore, that all the little folds of the body—between the toes, etc.—be dried carefully.

Children begin to walk between 12 and 18 months. Heavy, weak children should be kept off their legs as long as possible. They begin to walk about the second year.

Teething. The beginning of dribbling is always an interesting event in the nursery, being a pretty sure forerunner of the cutting of the first tooth. The milk teeth are 20 in number, and the first that should arrive are the two middle ones on the lower jaw: these are generally cut about the seventh month, the two front teeth of the upper jaw about the ninth, and the other two front teeth of the same jaw just afterwards. The remaining two front teeth generally come at the close of the first year; at the same time the first four double teeth appear, so this is a troublesome period in child history. The last four double teeth appear about the twenty-fourth month.

If teeth are cut out of their proper order, it is of no importance, provided they are not too long delayed. If they are backward, a little phosphate of lime, given with white sugar, will soon bring them on.

Ailments of Young Children. During teething, children are specially liable to convulsions, bronchitis, diarrhœa, and general nervousness. It is the later teeth that give the most trouble. It is a good practice to give them a hard substance to gnaw, but lancing the gum is not generally required, nor is it beneficial. Easy cutting of teeth is a good indication of general good health.

The ailments of children spring, in nine cases out of ten, from the stomach and from errors of diet. Diarrhœa is a common trouble, but is sometimes also an epidemic and a dangerous disease in itself. It should never be allowed to continue, and if there be any evidence that the food is not being digested, an appropriate change will at once cure it. Medical advice in any case should be sought early. Constipation is not uncommon, but should never be relieved with strong drugs. A little cold water is an excellent purgative; combined with a little glycerine it is stronger. A little oatmeal water when young, or a little porridge when older, will soon cure constipation.

Vaccination is best carried out before the teething sets in, and should always be done thoroughly, as smallpox is very fatal in infancy. Care should be taken that the lymph is obtained from a healthy baby, or fresh from the calf.

How a Child Should Sleep. A child ought not to sleep alone during the first few months of its life, but afterwards it should always sleep in a cot, and not in a bed. When in bed with its mother its face should invariably be turned away, for fear of being overlaid, and the face should *never* be covered. During the first year the child should average 18 hours' sleep, and after should decrease to about 12 at five years of age

With regard to indiarubber "comforters," a point that is often overlooked, it is important to know that it does far more than spoil the shape of a baby's lips. It has been recently pointed out that the prolonged sucking makes the roof of the mouth painful and swollen, and many serious alterations in the mouth, nose, pharynx, and ears, are the direct consequence of breathing through the mouth, brought on by sucking the solid rubber teat known as the "comforter."

Continued

RAILWAY SIGNALS & BRAKES

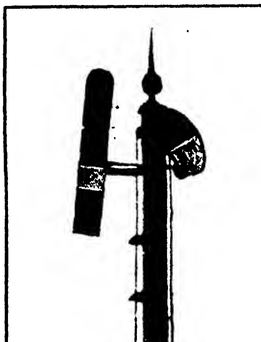
Varieties of Signalling Systems and their Methods of Working. Railway Brakes. Vacuum and Westinghouse Systems

continued from page 4601

By H. G. ARCHER

BRITISH railways are worked on the absolute block system, the object of which is to maintain a certain interval of space between all trains, instead of an uncertain interval of time as formerly. The line is divided into sections, varying in length from a few chains to several miles, according to the volume of traffic. A signal-box is placed at the termination of each section, and provided with a number of fixed signals outside, and within are the levers that actuate the movements of the latter, together with electric bells, block telegraph instruments, telephones, etc. The principle of the block system is that two trains travelling on the same set of rails shall never be in the same section at the same time, though this rule is relaxed in certain circumstances by employing what is known as the *permissive block* system, which is governed by stringent conditions.

Semaphores. The form of fixed signal generally adopted is the semaphore, which consists of a timber or iron pole, varying in dimensions according to circumstances, but usually from 20 ft. to 30 ft. high, with an arm about 5 ft. long, capable of assuming two positions when actuated by mechanical force. When this arm is in its normal position—namely, horizontal and at right angles to the post—it signifies "stop"; when it is nearly vertical it indicates "go on." Of all semaphore signals none has a less equivocal "go on" or safety position than the Great Northern pattern [16]. The arm being centre-pivoted does not fall, but jumps out from the post, and turns a somersault, so to speak, in assuming a position quite parallel with the latter. The face of every semaphore signal is painted red, with a white band, spot or stripe; while the back is painted white, with a black band, spot or stripe.



16. G.N.R. CENTRE PIVOTED SEMAPHORE

Selection of Position of Signals. All semaphore signals are placed in such a way that on approaching them the arm appears on the left hand side of the post, and, except where the line curves sharply, the signal posts are kept as far as possible on the left-hand side of the track, in the direction in which the trains travel. When two or more posts are clustered together, controlling several lines of way, the signal on the extreme left refers to the track on the extreme left, and the second to the second from the left, etc. In the signalling of two or three lines of way branching out from a common line at a junction it is, however, usual to bracket the posts, in which case the posts often number in height from the right, the tallest referring to the fast or main line, the next highest to the second line from the right, etc. In the event of the main line being on the extreme left, this procedure, of course, is reversed. At junctions, the posts, whether placed separately or bracketed, agree with the geography of the route. Some companies further distinguish the signal arms that refer to the slow or loop lines by giving them hoops. Three or four arms referring to different lines should never be placed one below the other on one post; each line should have a separate post or bracket.

Different Kinds of Signals. Fixed signals are distinguished as follows: home, distant, starting, advanced starting, siding, calling on, backing, and shunting. The home signal is placed close to the point at which it is desired that a train shall stop, and at such a spot that a driver may run up to it without any fear of being foul of points and cross-overs which such signal is intended to protect. The distant signal is placed at varying distance behind the home signal—that is, a driver comes to it first—according to the gradient of the line and other circumstances, but 1,000 yards is about the limit. Its function is to repeat the action of the home signal, so that if the latter is at "danger" a driver has timely intimation of the fact, and can at once reduce the speed of his train so as to stop at the home signal.

We do not speak of a distant signal as being at "danger" when the arm is in the horizontal position, but as at "caution." This is the only signal which a driver may run past when it does not signify "all right." "Distant" signals are distinguished by a fish-tailed end, and, together with "starting" and "advanced starting" signals, they are interlocked so that they cannot be taken "off" until the corresponding home signal has been lowered. Starting signals are usually placed at the end of the platform at a station, and they indicate to the driver when he may start his train and enter the section in advance, provided that there is no "advanced starting" signal, but where the latter exists the starting signal gives only permission to go on to the advanced signal. The advanced starting signal is placed some distance in front of the starting signal, and enables a train which has been allowed to pass the latter,

for the purpose of picking up waggons from sidings or to clear the section in the rear, to be brought to a stand without entering the section in advance.

Some Minor Signals. "Calling on" and backing signals have shorter arms than those of the ordinary type and also of somewhat different pattern. The former are usually placed upon the home signal post, below the home arm, and connected to the siding points to which they refer.

However, most shunting and siding operations are controlled by ground disc or dwarf signals, which notify to a driver when he may leave and enter a siding, or when he may cross over from one track to another. These signals furnish the required indications as to the state of the line. We have said that ordinary signal arms ought never to be placed one below the other on the same post. Nevertheless, in cases where the block sections are short, and consequently signal-boxes are situated near together, it is advisable to have the "distant" from the one box placed upon the home, starting, or advanced starting post of the next, when the "distant" must be the lower arm. Both signals must be mechanically "slotted" in such a way that the "distant" can never be taken "off" when the "home" above it is "on," while in order to avoid the discrepancy of the "distant" showing "off" when the home is "on," the home signalman must be able simultaneously to place both to "danger" as soon as a train passes.

Indications at Night. Signal arms, discs, etc., of course, cannot be seen at night, so the indications have to be given by a lamp working with the arm in a frame containing coloured glasses, termed *spectacles*. These latter cause the lamp to show a red light to indicate "danger," and a green to indicate "safety." No other light is allowed. Several attempts have been made to differentiate "distant" signals at night, by equipping them with purple and white glasses to indicate "caution" and "safety" respectively, but now they show the same lights as all other signals. In the United States a fairly satisfactory yellow light for distant signals has been evolved. Knowledge of the road alone enables a driver to distinguish a "distant" signal at night.

Interlocking Signals and Points. But the fixed signals do not do more than direct train movements. To turn a train off one line of way and on to another connecting with it, a pair of tapered movable rails, called *switches* or *points*, are utilised. If these points lie towards a train they are termed *facing points*; if in the reverse direction, *trailing points*. Facing points are usually to be avoided as much as possible. Thus, a train generally enters a siding, or crosses from one line of way to another by means of trailing points—that is to say, it backs. Both signals and points are actuated from a signal cabin, and in order to prevent contradictory movements on the part of each, the signal and point levers are concentrated in one frame, and mechanically interlocked. Consequently, the locking frame of an important signal cabin is a wonderfully complex piece of mechanism. Among the refinements that tend towards the perfection of interlocking, mention must be made of the following. The *locking bar* is a long flat bar lying along the edge of a rail and close to a switch. Each time the switch is moved this bar must be raised above rail level; thus, a train travelling through the points is master of the situation; not even the signalman can either intentionally or inadvertently change their position. The *detector lock*, if, owing to a broken rod, the points have not been moved, prevents the signalman from lowering any signal which would be contrary to the actual position of the points themselves. The *facing point lock* ensures that the points are properly set close home to the stock or fixed rail; otherwise the road cannot be signalled clear. The *clearance bar* consists of a series of locking bars, placed between the starting signal and the signal-box, and so long as a train is standing upon this portion of the line the block instrument and home signal are automatically locked at danger, and a signalman is unable to commit an error should he have forgotten the presence of the train in question.

Manual Operation of Signals and Points. Signals are worked by wires, and the points by rods connecting with their respective levers. Levers are of sufficient length to enable the signalman to manipulate them with moderate exertion, but, where signals are placed at long distances from the levers controlling them, counter-balance weights are provided both on the lever and the signal post to assist the operator. It should be added that the Board of Trade limits the distance at which trailing points may be manually worked from a cabin to 300 yards, and that of facing points to 250 yards.

The Signal-box. Great care is taken in the design of signal-boxes so that they shall be light and airy, and give those in charge a clear view of the track from every point. A gallery often runs along the front of the box, so that the signalman can go out to transmit messages to engine-drivers, guards, shunters, etc., without losing audible touch of his electric bell instruments. Every lever in the frame is numbered, and on the floor beside it or on a board in front of the frame there is fixed a brass plate engraved with its name and use—namely, "Up home," "Down advanced starting," "Main line cross over," etc., etc. Sets of levers are distinguished by being painted in different colours below the handle and spring catch. The following is the standard colour arrangement: red for home signals, green for distant signals, black for points, white for spare levers, and fancy hoops for anything out of the ordinary. In junction boxes it will be further observed that many levers bear an array of numbers, sometimes a dozen or more. These numbers form the key to the interlocking. Before any numbered lever can be moved, each of the levers to which the numbers on it refer has to be pulled over in the order in which the numbers run. Above the lever frame hangs a shelf on which stand the block telegraph and bell instruments, repeaters, route indicators, telephones, etc., and above the

17. INTERIOR OF A SIGNAL-BOX WITH "CREWE" ALL-ELECTRIC SYSTEM

shelf is displayed a large chart of the tracks, sidings, switches, cross-overs, and fixed signals, controlled and operated from the cabin.

System of Signalling. The two block telegraph instruments—one communicating with the signal-box on one side of him and the other with that on the other—instruct a signalman when he is to move his signals. The instrument consists of bells, possessing different tones for the boxes on each side of him, one bell serving for both "up" and "down" lines respectively, and of dial instruments. The former are used for calling attention, and for giving the complete code of signals descriptive of the nature of the trains. The latter, by means of a needle, miniature semaphore, or revolving shutter, give visible indications of "line blocked," "train on line," and "line clear." The normal state of the indicator is "line blocked." On the approach of a train to A, the signalman there will call the attention of B, by means of a given number of strokes on the bell to indicate the nature of the train. The signalman at B, if the previous train has passed his cabin, and he knows that the section A B is clear, repeats the signal correctly, and pegs the indicator to "line clear." The train is then despatched from A, the signalman at A gives the bell signal "train on line," and B acknowledges this by moving his own indicator and the one at A to "train on line." B then calls the attention of C with the "be ready" bell signal. When train has passed B, B puts his block instrument to the normal position, "line blocked." And so on throughout the block system. The "be ready" or "is line clear?" signal must never be sent until "line clear" has been received for the previous train, and the indicator has been put to "line blocked." If the second train should arrive at the signal-box before the preceding one has been signalled as "out of section," it must be halted and detained at the starting signal until the section ahead is clear.

An instrument of the needle type is worked with a handle, and that of the revolving disc with tapper keys. Instruments for both the "up" and "down" lines are now usually contained in one case, thus effecting economy in shelf accommodation.

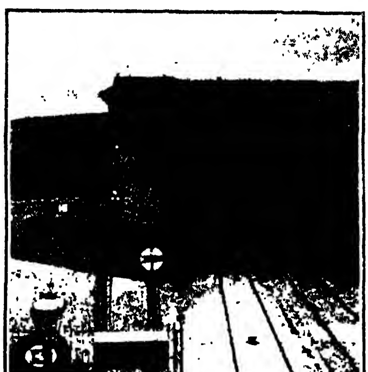
"Lock and Block." Obedience to the audible and visible instructions conveyed by the block telegraph instruments means that signalmen would never lower the fixed signals so as to permit of two trains being in the same section at the same time. Nevertheless, the human equation is liable to err; therefore, as a further safeguard, the block and interlocking systems have been combined, by means of electrical apparatus, whereby either the train itself assists in providing for its own safety by telegraphing its arrival at and departure from signal-boxes, or the signals, say, at B, are placed under the physical control of A and C—that is, the signalman at each side of B. This is known as the "lock and block" system, and it is employed only on sections of line where a large number of trains run with short headway. Undoubtedly, the best known and most widely applied "lock and block" system is the Sykes, with which a signalman is unable to lower the signal that admits a train to the block section ahead until the signal has been electrically released by the signalman at the box in advance, who cannot so release the signal until the

preceding train has passed over a rail contact in advance of his own starting signal, and that signal, again, has been put to "danger."

There is a variety of other "lock and block" systems which, without employing rail contacts or treadles actuated by a train itself, electrically unite the block telegraph and interlocking apparatus, so that they cannot be manipulated in a contradictory manner.

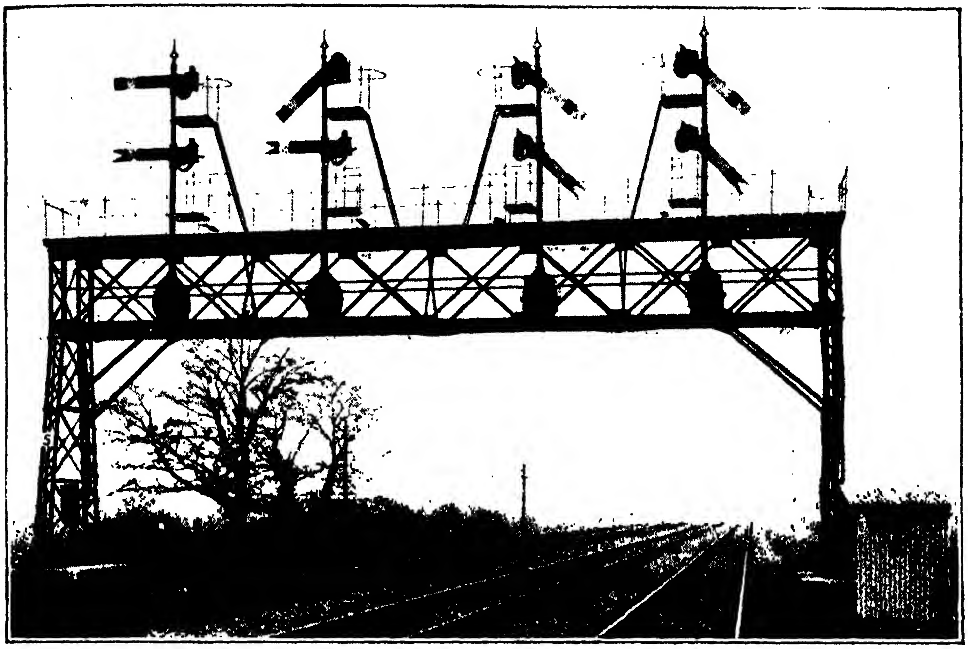
Electricity in Signalling. The function of electrical signal repeaters and light indicators is to inform the signalman whether the arms of such signals as may be hidden from his sight, by reason of curves or other circumstances, have acted in accordance with the movement of his levers, and also, during the night, whether the lamps keep alight. The movements of a signal arm are faithfully repeated by a miniature semaphore in a case, and similarly a little disc inscribed "light in" changes to another inscribed "light out" should the lamp fail. With many patterns of repeating instruments one wire only is required between the signal and the instrument to show all five indications—namely, arm "on," "off," and "wrong," "light in" and "light out." At big junction and terminal station boxes several other kinds of electrical instruments for the guidance of signalmen are in use—namely, train-starting indicators which announce when trains are ready to start from certain platforms; route indicators, by means of which signalmen are advised beforehand of the route an approaching train is required to take where several routes diverge; and shunting indicators.

Power versus Manual Signalling. Various new systems of signalling have been prominently to the fore in recent years in consequence of the large increase of traffic (which has necessitated a greater number of tracks and considerable enlargements of stations and yards), causing a distinct demand for some form of operating signals and points which shall give greater ease and safety in handling heavy traffic, together with more economical working than can be obtained by ordinary manual plants. The feature of a power system is that the signalman is provided with means for easily moving points and signals by electric, electro-pneumatic, hydraulic, or electro-hydraulic power. As with the manual system, it is necessary to have levers in a signal-box interlocked with each other, and connections between the box and the points and signals. With some power installations, like the Westinghouse and the "Crewe," the ordinary mechanical levers [17] are retained in miniature; thus, the signalman has nothing new to learn in the way of movements or catches. As a rule, however, the interlocking machine for a power system is smaller and more compact, and it is possible to interlock points and signals by return connections to the levers in the box. A signalman, therefore, when moving a lever is made aware that the point or signal has answered his lever. Again, with several power systems, should a signalman omit to put a signal to danger it will be thrown up automatically by the passage of a train. The connections with the signal and switch motors are invariably underground, and it is now agreed on all hands that surface rods and wires should be abolished in station yards, on account of the great risk to railway officials from exposed gear. Moreover, with the connections laid underground mechanisms are not liable to accident, neither can they get clogged with snow, ice, or dirt. Train movements can be effected much more rapidly by means of a power installation than by any manual plant. With the former the levers are nearer together, and the physical effort required to move them is too small for notice. Then, it is claimed that the automatic return indication relieves the signalman of considerable mental strain, so that not only can one man do the work of three, but he does it with less mental and physical effort, and consequently with less risk of being overcome with fatigue during long hours. Other advantages possessed by power systems are the fact that the Board of Trade permit facing points to be worked at a greater distance from the signal-box than with a manual, that little difficulty is experienced in "leading out" of a signal-box a maze of connections in many lines of way, and that the cost of maintenance is small. On the other hand, with a manual system, power costs nothing, it being provided by the signalman; and in the initial cost of installation a power plant is considerably greater, while specially trained men are required to supervise it. To sum up, although power signalling effects a considerable saving in working and maintenance expenses, the increased cost of installation largely precludes its adoption, except at busy centres, where, however, power signalling is undoubtedly more economical, and here also the system offers the advantage that, the operation of the levers being quite easy, the signalman is able to devote himself entirely to outside operations.



18. SYDENHAM HILL TUNNEL ELECTRO-MECHANICAL SIGNAL

Growth of Power Signalling. Within the limits of this paper it would be impossible to discuss the technical details of the various power systems partially adopted by different companies. Suffice it to say, therefore, that the London and North-Western Railway employs the "Crewe" all-electric system; the North-Eastern, Great Eastern, Lancashire and Yorkshire, and Metropolitan-District Railways, the Westinghouse electro-pneumatic (normal pressure); the Great Western Railway,



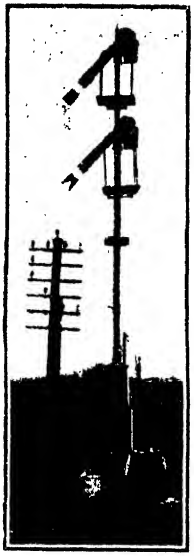
19. AUTOMATIC SIGNALS, LOW-PRESSURE PNEUMATIC SYSTEM, L. & S.W.R.

the Siemens all-electric; and the Glasgow and South-Western, and South-Eastern and Chatham Railways, the Sykes electro-mechanical. It is commonly supposed that power signalling came to us from America. The idea originated however, with an Englishman, Mr. W. R. Sykes, who in the early seventies took out the first patent for operating signals by power, and in 1875 installed the first power signals in the world actuated by electricity at the portals of the Sydenham Hill tunnel. These latter signals [18] consist of a red banner, moved on a spindle, to which is attached an armature with an opal background, through which a lamp shines at night, and so the signal takes by night the same form as by day.

Automatic Signalling. A further development of the power system is automatic signalling, whereby the trains are made to signal themselves. There are several different kinds of automatic signalling systems [19-22] in vogue, but one feature is common to all—namely, an electrical wire and track circuit circulating over each block section. The currents are furnished by gravity batteries, and are of low tension, inasmuch as they do not perform the signal movements, but are required merely to regulate the actual motive power, which is led through valves to the signal motors. The motive power is usually compressed air, as in the case of the London and South-Western and Metropolitan-District Companies' installations; but the North-Eastern Railway employs cylinders [20] charged with liquid carbonic acid gas at a pressure of about 800 lb. to the square inch. The gas motor possesses the advantage of obviating the employment of an air-compressing plant and pipe-lines. The Great Western Company is trying an all-electric system.

When a train enters a section its wheels short circuit the track battery—that is to say, the current flows through the axles, thereby putting the actual motive power into operation to set the signals which it has just passed at "danger." The train having cleared block 1, and entered block 2, the current of the track battery is again flowing through the rails, thereby causing the signals to resume their normal position. With some installations, while the circulation is free, the semaphores stand at "safety," but with others, the normal positions of the signals conform with the Standard Block Regulations—namely, "Danger," and on the approach of the next train, the line being clear, a mechanical contrivance attached to the section enables the signal to drop at "clear."

The advantages of automatic signalling are as follow: augmented track capacity, for it enables a greater number of trains to be passed over a given stretch of track; uniform running of trains; the guarantee that the section is clear for a train, and that the track itself is in good order. It cannot, however, be utilised at junctions, and as our railways are punctuated with these to an elsewhere unparalleled degree, there is not the same extensive field for its employment in this country as in America. Trips or train stops [23] form another new refinement. They automatically prevent trains from over-running home signals. The apparatus consists of an iron arm between the track rails, acting in unison with the adjacent signal. While the signal is at "danger," this arm is elevated to a position in which it engages with a cock on the

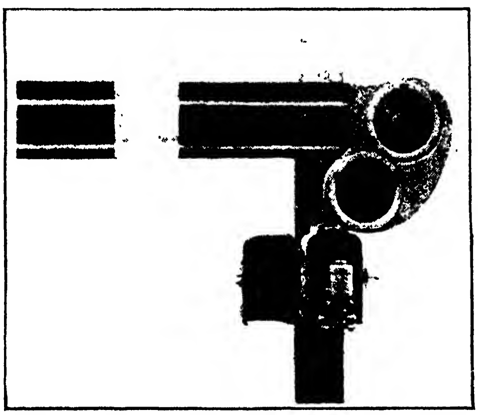


20. ELECTRO-GAS AUTOMATIC SIGNALS, N.E.R.

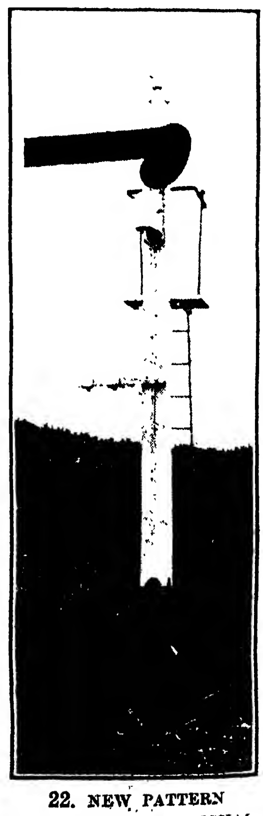
brake pipe of a train. Thus the continuous brake is instantly and automatically applied if by any chance the driver should run past the signal.

Signalmen. As a rule, the selection of candidates for the post of signalman, together with the training and allocation of signalmen, rests entirely with the traffic department. The practice observed in the main by all companies is to appoint youths between fourteen and sixteen years of age as lad-porters, and those among them who wish to become signalmen are at once allowed to learn single-needle telegraphy. Again, a lad between the ages mentioned may join a company's service as telegraphic messenger, earning between 6s. and 14s. per week, and at once devote himself to learning the use of the single-needle instrument. A sharp lad will be able to receive and transmit telegraphic train messages in from four to six months' time, and when he has demonstrated his ability he is placed in a large signal-box to act as telegraphist or train boy. Here his duties are to read and transmit telegraphic messages, and to write up for the signalmen the train books that record the times at which every train is accepted into the block section and clears it. While acting as train boy, a youth soon gets thoroughly acquainted with the working of the block telegraph instruments, the diagram of the line, and interlocking. Some companies keep train boys until they attain twenty years of age, and then allow them at once to pass the examination before the district superintendent for promotion to third-class signalman. Others, however, relieve the lads of their duties at seventeen years of age, and compel them to revert to porters, lamp-men, shunters, or clerks for a period of three or four years. This latter rule holds good with companies which will not appoint a man as a signalman until he attains twenty-three years of age. When a man who has not previously acted as train boy, or learnt single-needle telegraphy, wishes to qualify for a signalman he is not allowed to take any steps to carry out his desire until he has been in the company's service for a period of six months. The procedure is then to despatch him in his original capacity, as porter, shunter, or clerk to some small station, where his ordinary duties are sufficiently light to enable him to learn the practice of signalling and single-needle telegraphy. It is not every company that insists upon the would-be signalman qualifying as a telegraphist, but a man not so qualified could never hope to rise above the rank of third-class signalman on a remote branch line. The same procedure is observed by the companies alluded to above, which do not allow train boys or boy-telegraphists to continue as such till they come to the limit of age for promotion to signalmen. The Great Western Railway has a school of signalling, the equipment of the class-room [24] including a scale model of a double-line junction, with interlocking frame, signals, points, sidings, rolling-stock, etc., in full working order.

The Complete Signalman. Having acquired a fair knowledge of signalling in a wayside station signal cabin, an aspirant is promoted to a more important station, where, besides fulfilling his ordinary duties, he is put on to relieve for a few hours at a stretch a fully-fledged signalman. Lastly, when a vacancy occurs, a man who thinks he has mastered the subject may apply to be examined for third-class signalman, either by the district traffic superintendent, or a signalling inspector, according to the company's practice. The examination is of a searching character. It generally comprises both oral and written examination in the working of the block system, any patent method of signalling, such as

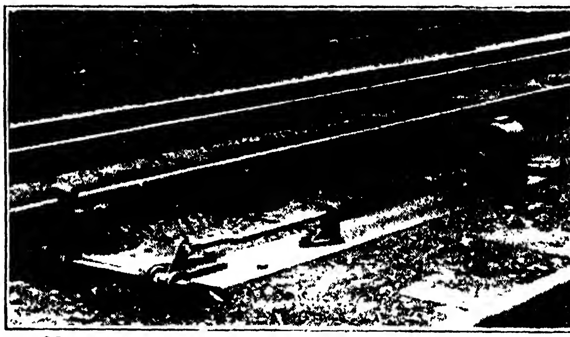


21. SIGNAL SHOWING WESTINGHOUSE ELECTRO-PNEUMATIC MOTOR



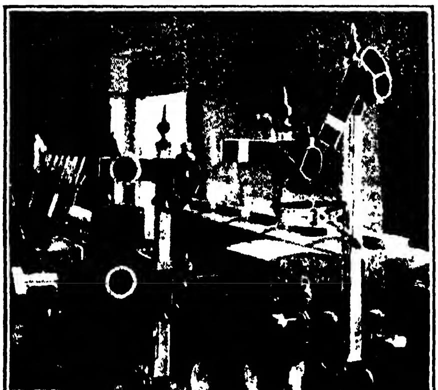
22. NEW PATTERN AUTOMATIC HOME SIGNAL ON DISTRICT RY.

the "lock and block," electric train staff or tablet system, etc., which may be adopted by the company in question, and "emergency" signals, or what to do in a dozen or more different kinds of accidents. Signal-boxes are classified as belonging to principal main lines, secondary main lines, and branch lines. In each of these divisions there are three different grades of signalmen—namely, third, second, and first class, and with some companies there are two higher grades on principal main lines—namely, "special" and "extra-special."



23. TRAIN TRIP: METROPOLITAN-DISTRICT RAILWAY

Pay and Promotion. The rates of pay vary not only according to class, but also according to division. Thus, a third-class signalman on a principal main line earns more than a first-class man on a secondary main line. Signalmen earn from 18s. to 25s. a week, and receive for correct working a bonus of from £2 to £5 per annum. All vacancies are posted among the men, and each man has a chance of applying for promotion, which is decided by seniority and merit. When a man is promoted to a fresh box, he is allowed a fortnight or so in which to learn it to the satisfaction of his superintendent before taking charge. Each signalman is responsible for his own block telegraph instruments, and his first duty after signing on in the train register book is to satisfy himself that all the electrical instruments, signals, points, etc., are in good working order. An adjusting apparatus enables him to adjust his signal wires for expansion and contraction from heat or cold without leaving his cabin, while the "point rod compensator" automatically compensates the rods which actuate the points. The signalman is responsible that his signal lamps are lighted and extinguished at the regulation hours and that they are lighted in foggy weather or during falling snow, but the lamps are trimmed, placed in position, lighted, and extinguished for him by porters or lamp men. A signalman's hours are never longer than twelve, and that only on unimportant branch lines, from eight to ten hours being the rule elsewhere. Where the work is heavy more than one man is put in a box, and when the telegraph work is heavy a telegraphist also is allowed. The stationmaster supervises the duties of the signalmen at his station, and must frequently visit the signal-boxes for the purpose. Every signalman is examined from time to time in all emergency working by his stationmaster and inspector.



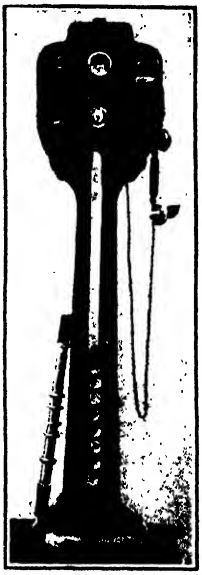
24. G.W.R. SCHOOL OF SIGNALLING
Model of Junction

Department of the Signal Engineer. When men are promoted from being signalmen, they usually go to the traffic department, becoming platform inspectors and rising to district traffic inspectors. The maintenance of the complicated array of signals, interlocking apparatus, and electrical instruments is a work of great magnitude. It is entrusted to a signal engineering department, which has nothing to do with the training of signalmen or manning of the boxes. The work of the department is divided into a mechanical and electrical side. To begin at the bottom, there are signal and telegraph linemen, who are responsible for the maintenance of a certain number of boxes, which they visit periodically according to roster. The signal linemen clean and oil the fittings of each signal and point, and execute any small repairs or renewals that may be required, but they are not allowed to tamper with the interlocking apparatus or to take in hand any important repairs or renewals. Signal fitters come round at less frequent intervals to overhaul, test, and clean the interlocking frames, facing point locks, etc., while heavy repairs and renewals are carried out by an extra gang attached to each district,

25. AUTOMATIC FOG SYREN OPERATED BY THE TRACK CIRCUIT

in charge of a responsible foreman. The telegraph linemen, however, are considered competent to overhaul the block telegraph and all other electrical instruments, in addition to recharging the batteries and mending broken circuits. These men maintain the Post Office wires under an agreement between the Post Office and the railway company. For the purposes of maintenance the whole line is divided into districts, each of which is in charge of both a telegraph and signal inspector. A special department often exists for carrying out new works, under the superintendence of a new works inspector, who acts directly under the head office. The whole organisation of maintenance is vested in a managing staff, which comprise electricians, draughtsmen, assistants, and clerks, all of whom are employed under the control of the chief of the signalling department.

Fog Signals. Some space must now be devoted to discussing the problem of signalling during foggy weather and falling snow, in which circumstances all the foregoing arrangements may be nullified by reason of the impossibility of reading the visual signals. A primitive procedure, still very widely practised, consists of posting men at the foot of the signal posts, where they can see the positions of the arms. So long as the signal indicates "danger," a fogman must place and keep one or two detonators according to rule—if two, ten yards apart—on one rail of the line for which the signal is at "danger" and exhibit a red hand-signal to the driver of an approaching train. When the signal is taken off, he must remove the detonators from the rail, and show a green hand-signal. To facilitate the work of the "foggers," and reduce the risks of an extremely dangerous occupation, it is now usual to have miniature signals on the ground, which either mechanically or electrically repeat the indications of the real arms; and, as a further safeguard, one company at least — the Great Eastern—have constructed fog-pits between the tracks in places where there are many lines of way. The repeating signals and fogmen are stationed in these pits. In the immediate vicinity of London and other large towns a regular staff of fog signalmen is employed at all the places where their services are required; elsewhere the services of platelayers are requisitioned. A list of the names and addresses of the fog-signalmen, showing the post to which each man is appointed, is exhibited in the stationmaster's office and signal-box.



26. WEBB-THOMPSON ELECTRIC TRAIN STAFF MAGAZINE

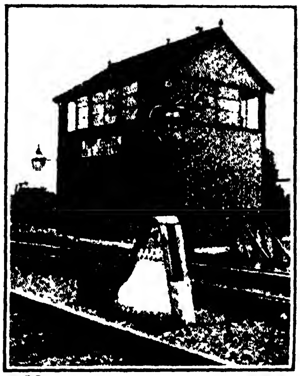
Mechanical Fog Signalling. The great defect in the foregoing system of fog-signalling rests on the fact that fogs often come on suddenly, when, until the "foggers" arrive, there is the risk of drivers running past signals at "danger," which, owing to the absence of a detonator warning, they believe to be all right. Inventors have been busy in seeking a solution of this problem for many years, and patents innumerable have been filed on the subject. Some of them would substitute a mechanical for a human arm in placing detonators on the rail, which mechanical arm could be fed from a magazine and operated from a signal-box. Others would fix a lever alongside the rails, so that while the signal is at "danger" it would engage with another arm projecting from the locomotive, and then produce some audible or visual indication, which could not fail to be heard or seen by the men on the footplate. But the weak point of any such system is sufficiently obvious. The force of the blow would be so great that with constant use the triggers would be liable to get thrown out of gear; while again, the triggers might become clogged with snow, ice, or dirt. Nevertheless, there is in use on the Great Northern Railway, at Doncaster, a rocker and trigger apparatus, which, thanks to an arrangement of double-coiled springs (with coils in reversed order) that distribute the force of the tremendous blow, claims to have surmounted the former difficulty at least. Further, the Great Western Railway is experimenting with an arrangement, partly mechanical and partly electrical, which claims to have overcome all the difficulties hitherto experienced.

The electrical track circuit, as employed for the purposes of automatic signalling [25], is another solution of the problem. Several inventors have demonstrated their ability to establish electrical communication between the signals and engine of an approaching train, viâ the track, and so to give audible or visual indications of "danger" in the "cab" of the locomotive itself.

27. ELECTRIC TRAIN STAFF "CATCHER" APPARATUS, G.W.R.

Staff and Tablet Working. The regulation of the traffic on single-line railways is accomplished either by an electrical train staff or tablet apparatus. staff or tablet, suitably inscribed, is delivered to the engine-driver at station A, and constitutes his authority to occupy the main track between A and B. On reaching B, he surrenders the tally, and receives another one, which gives him the right to the road between B and C. The tallies, in any desired numbers, are kept at each of the two

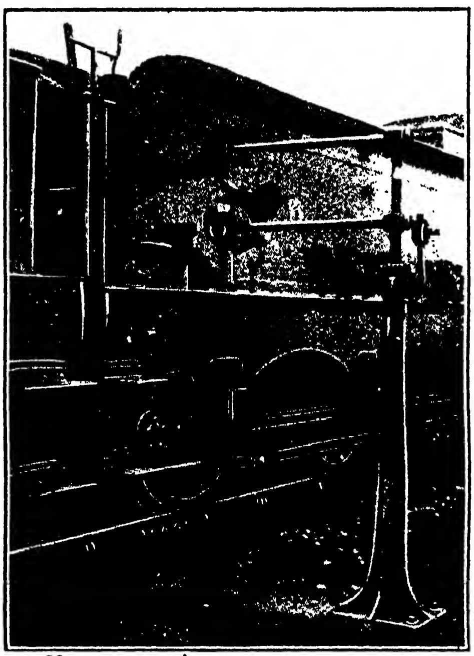
stations, and are locked in a cabinet, automatically controlled through electromagnets by an apparatus in the cabinet at the other station. And a staff or tablet being taken out at one station, a second one cannot be taken out at either station until this first one has been returned to the magazine at one station or the other. Thus, to get two trains in the same section at the same time is impossible. One line wire is sufficient for all purposes—namely, operating the staff or tablet instruments [26], giving code signals on bell, and for telephonic communication. When it is required to work permissively a single line equipped with the staff apparatus the following method can be adopted with perfect safety. Each staff can be made up of three portions coloured distinctively. The end portions, coloured red and blue respectively, are denoted as "tickets;" while the centre and fundamental portion, coloured yellow, is called "staff." When it is desired to send three following trains from station A to station B, an entire staff is withdrawn from a magazine in the ordinary manner. The first and second driver each take a ticket, and see the staff. The third driver will take the staff. It is physically impossible to replace the staff in either instrument until the three portions are screwed together, and until this is done both instruments remain locked.



28. WHITAKER'S ELECTRIC TABLET RECEIVER
Special apparatus

Exchanging Apparatus. On some lines, in order to avoid stopping at stations to discard one tally and pick up another, what are called staff "catchers," or tablet "snappers," are employed. A "catcher" [27] usually denotes an apparatus for exchanging the full-sized staff instruments, which are especially equipped with ring-handles. It is a very simple contrivance. By the side of the line is fixed a post, with an arm projecting to the driver, and shaped to receive the staff for the section the train has just passed through. A driver hangs the staff by its handle on to this arm, which projects from a leather padded target, in order to absorb the force of the blow. A few yards farther on is another post with a pocket into which is placed the staff for the section in advance. The driver plucks out his staff as he passes the post. At night the target-arm and fresh staff are made prominent by means of lamps, carried on a separate post in the case of the former, and bracketed to the second staff post. With this exchanging contrivance a train need slow down to only about 20 miles per hour.

It has long been customary to exchange electrical train tablets, which are small discs looking like quoits, at higher speeds by hand. The tablets are placed in pouches furnished with wire hoops, and through the latter the driver and signalman respectively thrust their arms as the train speeds by. But the practice is a somewhat risky one, hence several automatic tablet exchangers or "snappers" have been devised.



29. WHITAKER'S COMBINED TABLET OR MINIATURE STAFF RECEIVERS AND DELIVERERS ON ENGINE AND ALONGSIDE TRACK

Whitaker's Tablet Exchanger. A very ingenious "exchanger" [29] has recently been invented by Mr. A. Whitaker, and is in use on the Somerset and Dorset Railway.

The locomotive tender is equipped with a catcher which slides in and out in a bracket, and is thrown out when it is required either to catch or discard a tablet. The aluminium tablets are placed in leather pouches furnished with rings. By the side of the track are placed columns having one or two different kinds of arms, according to whether the column in question is for setting down, picking up, or exchanging tablets. If the last-named, two arms are necessary, the upper one being the setting down arm, and a replica of the fish-tailed catcher on the tender, the jaws of which have three triggers. A tablet to be discarded is carried in a slot at the back of the tender catcher, and is snapped off by the ring passing through the jaws of the catcher by the side of the track, while a tablet to be picked up is hung from its ring on another arm, and snapped up by the tender catcher. The arms normally stand in—that is, are parallel with the track, and when to be used are thrown out by levers. An outstanding feature of the apparatus is, however, the automatic return of the arms to the normal position directly the process has been effected. Otherwise, the fact of the arms being left to project

diagonally so close to a train would be attended with serious risks. The "snapper" performs its work at a speed of sixty miles per hour.

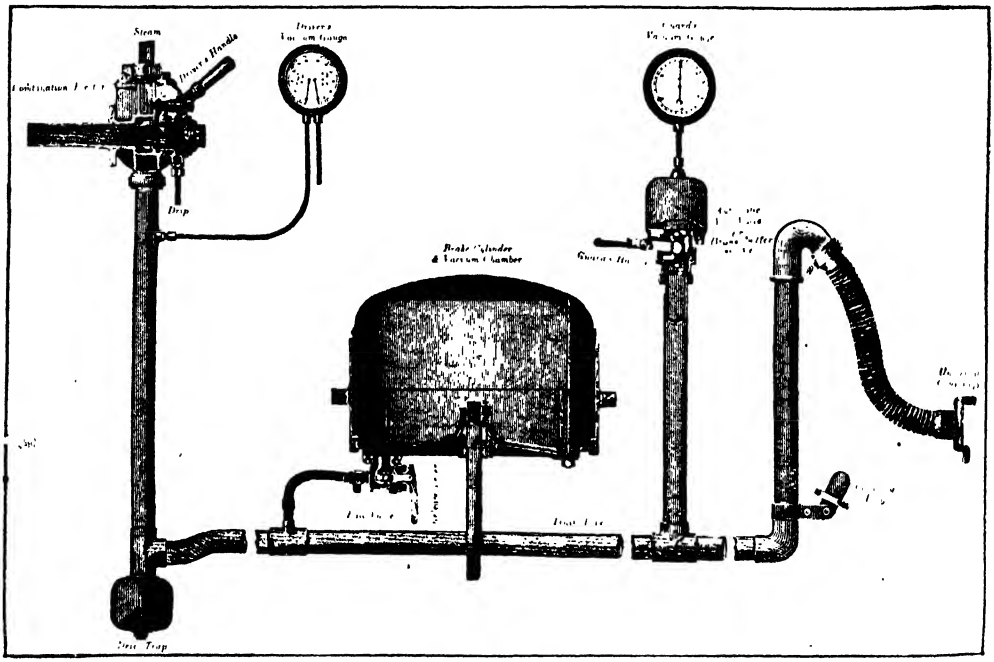
In one particular instance, however, it was not found practicable to place a receiver by the side of the track; it had to be located in the six-feet way, thus necessitating a special design. With this type of receiver the arm is set vertically [28] for an approaching train, and drops down vertically—backwards—instead of revolving horizontally, directly the catch off the tender is effected.

In many cases, by the use of electrical train staff and tablet instruments, together with exchanging apparatus, the facilities for working the traffic are so improved that the doubling of single lines and the consequent capital expenditure may be postponed for years.

gradually evolved from the hand-operated screw brake that formed the earliest method of retarding the motion of trains.

The basis of a continuous automatic power brake is an apparatus fitted to each wheel of every vehicle composing a train, so that every engine, tender, and vehicle has its own store of brake force ready for instant use, while its action is such that if every or any coupling in the train separate, the brake of each vehicle is automatically and instantaneously applied. The brake is capable of application by the engine-driver and by any of the guards.

Unfortunately, British railways have been unable to agree upon uniformity of brake system. At the present day 59 companies are returned as using the automatic vacuum, and 17 companies the Westinghouse automatic air brake.



30. ORDINARY VACUUM AUTOMATIC BRAKE

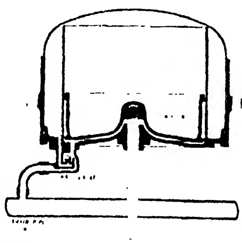
Railway Brakes. A fact little realised by ordinary railway passengers is that the attainment of the present high speed of our trains was made possible only by inventions of suitable means of controlling them. In itself, the ability of trains to travel at high speed would have been not only a useless but a dangerous thing had it not been accompanied by such improvements in railway brakes as enabled drivers and guards to control the tremendous energy set up by heavy trains travelling at high velocities.

The history of railway brakes is a long and complicated one, which cannot be related here. Suffice it to say that the continuous automatic power brake, the compulsory equipment of which to all passenger trains was brought about by the Railway Regulation Act of 1889, was

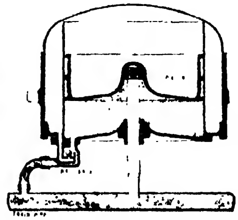
The "Ordinary" Vacuum Automatic Brake. This brake stops the train by the application of brake blocks to the tyres [33] in the same way as the ordinary hand brake. The levers, however, which apply the blocks are moved by a piston working in a cylinder, the piston deriving its power from the pressure of the atmosphere. It is continuous, each vehicle carrying its own brake cylinder, which is connected to a pipe running from end to end of the train, and through this pipe the action of the brake cylinders is controlled on the engine. A combination ejector, consisting of two ejectors known as the "large" and the "small"—the latter being placed inside the former, and worked continuously, while the "large" is worked by the admission of steam—exhausts the air out of the continuous pipe and the cylinders. The brake is applied by the

admission of air into the train pipe, and released by the withdrawal of the same through the ejector.

The engine having been coupled to the train, and the hose couplings connected between the tender and train, and also between the coaches, and the one at the end of the train having been placed upon the plug, the driver admits steam to the small ejector, which soon exhausts the train pipe and cylinders to a vacuum of from 20 in. to 24 in., or the large ejector may be used if the vacuum is required to be obtained more rapidly. The small ejector must be kept at work continuously to maintain the vacuum. To apply the brake, the driver moves the handle of the combination ejector in the direction marked "On," thus admitting air to the train pipe and to the bottom of each cylinder, which lifts the pistons and so pulls the blocks to the wheels. The air cannot pass to the top of the piston, as it is prevented by the



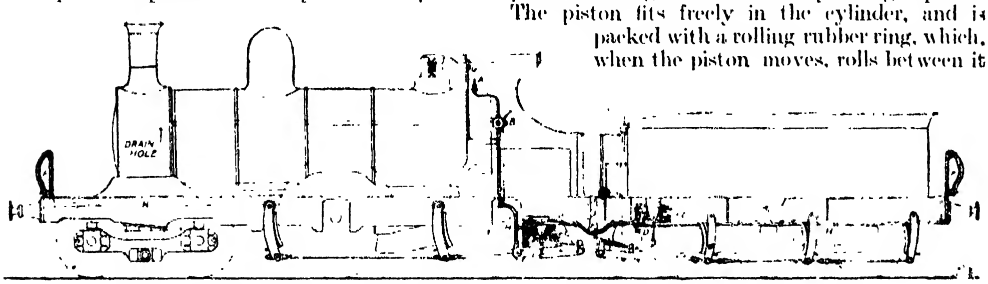
31. VACUUM BRAKE, "ON"



32. VACUUM BRAKE, "OFF"

vacuum, say from 5 in. to 10 in., which should be recreated slowly as the train comes to rest by placing the handle in "Running Position." To apply the brake quickly the handle must be moved to the position marked "On," thus fully opening the air valve. The guard can apply the brake by pressing down the handle of his valve, the "brake setter-valve," thus admitting air and applying the brake throughout the train, which it will stop even if the engine remain under full steam. When a rapid application is made by the driver, the guard's valve opens automatically, letting in air from the van, thus increasing the rapidity of application, and it closes again after the brake has been fully applied.

Arrangement of Brake Cylinder and Vacuum Chamber. The brake cylinder and vacuum chamber is shown in section in 30, self-contained in the vacuum chamber as applied to carriages, and is the only fitting required. The piston fits freely in the cylinder, and is packed with a rolling rubber ring, which, when the piston moves, rolls between it

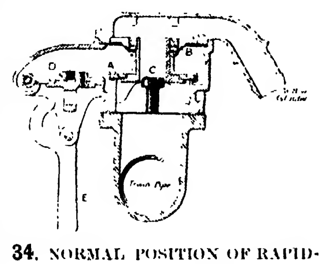


33. AUTOMATIC VACUUM BRAKE AND CONNECTIONS ON ENGINE AND TENDER

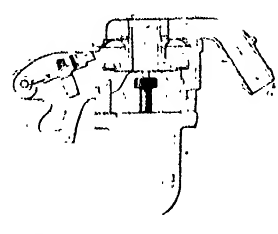
screw-stop valve B. Combination ejecto Brake cylinder . Ball valve E. Drip trap F. od coupling G. Vacuum g H. Train pipe Vacuum chamber

ball in the ball valve. The power of the application is controlled by the amount of air let into the continuous pipe.

To release the brake, the handle must be returned to "Running Position," when the air let in to apply the brake will be removed through the small ejector; or it may be released more quickly by pushing the handle in the direction marked "Off," and so admitting steam to the large ejector. The brake having been applied, the pressure of the blocks on the wheels may be increased or diminished at pleasure without removing them, and also without reducing the full reserve power of the brake, which is always at command for an emergency stop. Ordinary stops should not be made by a violent application of the brake, but by a destruction of



34. NORMAL POSITION OF RAPID-ACTING VALVE



35. RAPID-ACTING VALVE OPENED AND BRAKE APPLIED

and the cylinder, making a perfect packing without friction. The piston rod is coated with brass and works through a brass bush, and a packing rubber prevents air from passing the rod. This rod should be kept clean by wiping with a dry cloth, but no oil or grease must ever be used. At the bottom of the cylinder is attached the ball valve, the branch of which is connected by a small hose pipe to the train pipe. This valve is of the most simple construction, as there is only one moving piece, and that being a small brass ball, having a rolling action in a horizontal position, has consequently no friction. The spindle with release lever is added for the purpose of withdrawing the ball from its seat when it is required to release the brake by hand—for instance, when coaches are detached

from the engine. This spindle is made air-tight by a small diaphragm, the pressure on which when a vacuum is created pulls in the spindle and allows the ball to go freely to its seat.

The action of the cylinder is as follows. The air is drawn out through the train pipe from the bottom of the piston direct, and from the top by passing the ball. To apply the brake, the air is let into the train pipe, and it then passes to the under side of the piston, and, being prevented from entering to the top by the ball, lifts the piston, and so applies the brakes with any amount of force according to the quantity of air let in. Fig. **31** shows "Brake on," and **32** shows "Brake off."

A drip trap is placed on the train pipe at the bottom of the down pipe from the ejector so that any moisture will drain into it. It is fitted at the bottom with a self-acting ball valve, which opens when all the vacuum in the train pipe is destroyed and allows the water which may have collected to run out.

Before starting, the driver must see that the gauge indicates at least 18 in. of vacuum, and that not less than this amount is maintained during the journey and while standing at stations. The vacuum is created by admitting steam to the small ejector by means of the steam cock on the combination ejector. The guard also must see by the gauge in his van that the proper amount of vacuum is maintained, or report otherwise to the driver.

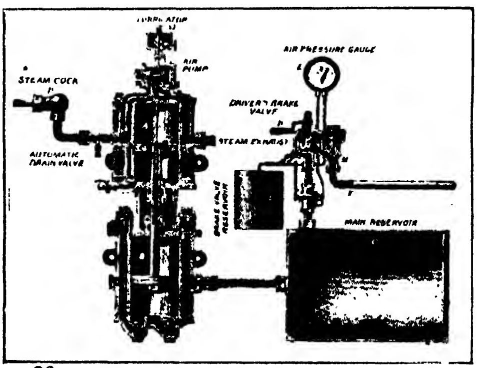
Rapid-acting Vacuum Brake. The rapid-acting vacuum brake — which can be used either as a "rapid-acting" or an "ordinary" vacuum automatic brake — consists of the addition of a rapid-acting valve. This appliance is mounted on the train pipe as near as possible to the brake cylinder, and is connected to the latter by the usual flexible hose.

The normal or "running" position is shown in **34**. A vacuum is maintained on the underside of the valve, A, and the top side of the diaphragm, B, the atmospheric pressure being free to act on the top side of the valve, A, and the under side of the diaphragm, B; but on account of an excess of pressure the valve, A, is held tight upon its seating.

When a rapid action of the brake is required, air is suddenly admitted to the train pipe and thus to the under side of the valve, A, then the pressure acting on the under side of the diaphragm, B, is sufficient to cause it to lift the valve, A, and allow air to pass full bore both to the brake cylinder and to the train pipe, as shown by **35**. Immediately the brake is "full on" the valve falls to its normal position by gravity.

To obtain a graduated application of the brake, air in moderate quantities is admitted to the train pipe, and the area of the passage around the peg, C, is proportioned so that it will allow the necessary amount of air to enter the brake cylinder, and so obtain a simultaneous action of the brake on every vehicle throughout the train.

Westinghouse Automatic Air Brake. Air pressure is the power employed for working the Westinghouse brake. Each locomotive carries its own air compressor, which is driven by the steam from the boiler of the engine, and compresses air to a pressure of about 80 or 85 lb. to the square inch, or, in the case of the quick acting brake, to 90 or 95 lb. When the locomotive is coupled to the train this compressed air, with which the main reservoir has been charged, is turned on to the main pipe running through hose coupling the whole length of the train, and thence through branch pipes leading to auxiliary reservoirs carried by each carriage. Thus, when the train is ready to start, the whole system of reservoirs and pipes is charged with an equal pressure of air, which is ready at any moment to act instantaneously upon the brakes by means of a device known as *the triple valve*. The following advantages and principles of operation are secured by this method of employing compressed air: (1) The power is continuous throughout the whole length of the train and can be applied to all vehicles either by the driver from the engine or by the guard from any part of the train. (2) The action is automatic, instantaneous, and simultaneous. It applies itself with full force to every vehicle should the train separate or should a rupture of a vital part of the apparatus occur. (3) The brakes are applied by a *reduction* of air pressure, purposely or accidentally produced. (4) The brakes are released by an *increase* of air pressure which can be produced by the driver only by means of the air compressor on the engine.



36. WESTINGHOUSE QUICK-ACTING BRAKE. PARTS APPLIED TO LOCOMOTIVES ONLY

We shall now proceed to describe in detail the operation of the Westinghouse quick-acting brake, references being made to the accompanying figures [**36**–**38**] showing sections of the various parts.

Parts Applied to Locomotives. Every engine is fitted with the following parts [**36**]:

The *steam air pump*, A, B, which compresses the air; its steam cock, P; and lubricator, O.

A *main reservoir*, C, for storing the air necessary for releasing the brakes and recharging the auxiliary reservoirs.

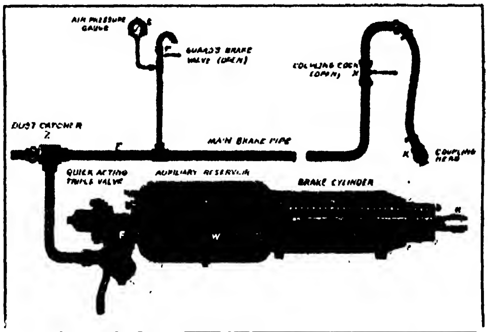
A *driver's brake valve*, D, which regulates the flow of air from the main reservoir into the brake pipe for charging the train and releasing the brakes, and from the brake pipe to the atmosphere for applying the brakes.

Parts Applied to Tenders, Carriages, and Vans. A *triple valve*, F, by means of which the instantaneous action is produced, in conjunction with a *reservoir*, G, in which is stored the compressed air for applying the brakes.

A *brake cylinder*, H, with pistons and rods connected to the *brake levers* and *blocks*.

A single line of *pipe*, E, called the *brake pipe*, extending the whole length of the train.

Each van has a valve or cock, T, connected to the brake pipe, and a gauge S, to indicate the pressure of air. By opening his valve a guard can stop the train, even against the will of the driver, if necessary.



37. WESTINGHOUSE QUICK-ACTING BRAKE. PARTS APPLIED TO TENDERS AND CARRIAGES

Operation of Brake. The pump [36] being started by opening the steam cock, P, and admitting steam to the cylinder, air is forced from the cylinder, B, into the main reservoir, C, which is connected to the driver's brake valve, D.

When a train is to be charged—the hose couplings between the carriages having been united and the engine connected to the train—the compressed air stored in the main reservoir, C, is turned into the brake valve over to the left. It then fills the brake pipe, and flows through the branch pipe on the engine and tender and each vehicle to the triple valve, F [37], thence by a groove, and past a piston into a reservoir, G, where it remains until the brake has to be applied. Uniform air pressure then exists throughout the train, except in the brake cylinders, H, the brakes being off; and the pressure per square inch is shown on the gauge, L, connected to the brake pipe.

So long as this pressure is maintained the brakes are kept off, as the passage from each reservoir to its cylinder remains closed by the slide valve; but letting the air escape from the brake pipe causes the triple valve pistons and slide valves to move towards the left and to uncover the passages to the cylinders. The air stored in the small reservoirs, G, then flows into the cylinders, H, and forces out the brake pistons and rods, thus applying the brakes. From the foregoing it will be seen that the driver can, by turning the handle of his brake valve, reduce the pressure in the brake pipe, and thus apply all the brakes.

Releasing the Brake. The brakes are taken off by reopening the passage from the main reservoir, through the driver's valve, and thus restoring the pressure in the brake pipe; this moves the triple valve pistons towards the right with their slide valves, and places the cylinders, H, in communication with the atmosphere by means of the exhaust cavity in each of the valves; the air used in the cylinders is thus allowed to escape, and the brake pistons and rods are pushed back to their places by springs inside the cylinders.

The driver's valve, D, shown in the diagram [36] is of the improved construction, with equalising arrangement. A small reservoir, U, is coupled to the nipple on the left of this brake valve.

Emergency Stops. The description so far explains the ordinary use of the brake. In an emergency, when the shortest stop possible is required, the brake valve handle should be thrown full over to the right, which movement lets out the air quickly from the train pipe. This sudden reduction of pressure makes the first triple piston and slide move the full stroke, with the effect that some of the air from the train pipe, together with the air from the reservoir, passes direct to the brake cylinder, H. The reduction thus made in the train pipe helps the next triple valve to start, and so on to the end of the train. This action is so rapid that the brake is actuated by the driver in 2½ seconds to the end of a train of 50 vehicles, not less than 1,500 ft. long.

The release of the brakes is made as previously described. The triple valve cock plug [37] and handle, Z, have three positions. When the handle is down, the triple will be in ordinary or quick action; when halfway, it is cut out; and when right up, in ordinary action only.

The ordinary Westinghouse brake, which works on the same principle but carries a simpler form of triple valve, is used where emergency short stops are not likely to be required. The high-speed brake is an improvement on the quick-acting brake, invented in order to graduate the high pressure between brake blocks and wheels, so that this shall be gradually reduced as the train slowed down, thus preventing skidding and undue wearing of the wheels. It carries a reducing valve, which gradually reduces the pressure as the speed decreases.

Evils of the Dual Brake System. The dual brake system is a fruitful source of inconvenience and additional cost, and sometimes, indeed, of danger to the safe working of a train as well. All the coaches of every Anglo-Scottish train have to be equipped with both the vacuum and air brakes, because the English companies concerned use the former and the Scotch the latter. Further, most of the railways are compelled to have a number of passenger train vehicles, such as family saloons, horse boxes, carriage trucks, etc., fitted with both systems of automatic brakes for the purpose of working through to "foreign" lines, while, again, companies which favour the vacuum brakes are bound to keep a number of engines fitted with Westinghouse apparatus, and *vice versâ*.

Continued

THE MYSTERY OF SOLUTION

Properties of Solutions. Colloids and Crystalloids. Gaseous Ions. What We Have Learned and How Far We Have Progressed

By Dr. C. W. SALEEBY

THE facts of solution and the facts of double decomposition, when fully considered, lead us to revise the idea that the dissociation of the electrolyte is due to the passage of electricity through it. It can be shown, indeed, that the electricity is not *used up* in dissociating the molecules of the electrolyte. There is already a good deal of freedom amongst the ions of the solute, or substance dissolved, even before the electric current passes. What the electricity does is merely to sort out the ions and force them to move against the resistance of the water. As to what solution really involves we cannot say. The ions of the solute must have relations which we cannot define with the molecules of the solvent, but they are, at any rate, independent of, or dissociated from, each other.

The dissociation theory does more than give us a complete explanation of the electrical and osmotic properties of solutions, or at least of aqueous solutions. It actually enables us to explain, in great degree, the chemical properties of such solutions - that is to say, it enables us to correlate their chemical and their electrical properties. The very solutions which exhibit the highest chemical activity are solutions of electrolytes—salts and acids— and their chemical activity is the activity of their ions. There are some chemical reactions in which "the electric charges on the ions seem to be the determining factors of the whole process."

Colloids and Crystalloids. But even yet we have not exhausted the chief aspects of the subject of solution. We can distinguish broadly between two large groups of substances. On the one hand, there are those which are crystalline in form, like salts in general, and for purposes of this comparison such bodies are classed as *crystalloids*. On the other hand, there are many bodies, most of them of organic origin, such as white of egg, which are not crystalline, or not definitely crystalline, and which markedly contrast with the crystalloids in respect of certain physical properties. These we call *colloids*, from the Greek *kolla*, glue, and *eidos*, likeness. The most outstanding distinction, perhaps, between these two groups of substances is that the crystalloids diffuse rapidly through water, whilst the colloids move slowly or not at all.

While the majority of inorganic substances are crystalloids, there are many exceptions, and under certain definite conditions compounds of iron, gold, silver, arsenic, bismuth and mercury can be obtained in colloidal form. If, now, we take a mixture of crystalloids and colloids dissolved in water and place them within a parchment or some similar membrane, the crystalloids will diffuse through while the colloids are completely arrested. Since the membranes of the body are colloidal we can readily guess that these facts must be very frequently and very importantly illustrated in physiology. In the living body, also, important consequences must result from the fact that there are two distinct classes of colloids: those—such as gelatin—which, when dissolved in water, can be made to "set," and afterwards redissolve, and those which, once thrown out of solution, remain insoluble. The first class of colloids are said merely to *set*, but the second class to *coagulate*. The first may be called *reversible* and the second *irreversible*.

Our Conception of a Solution. Again, we find that different parts of our subject become interwoven with one another. In the case of the irreversible or coagulable colloids we find that their precipitation is greatly aided by the addition of the minutest quantities of the solution of a salt or other electrolyte, and, furthermore, it has been lately shown that the coagulative power of the electrolyte has a definite relation to the valency of its basic or metallic ion.

We are now able, perhaps, to form some kind of picture of a solution in terms of the dissociation theory. We cannot form any picture of the relation of the solute to the solvent, but at least we begin to understand the state of the solute itself.

Says Mr. Whetham: "A certain number of the dissolved molecules are regarded as dissociated into charged ions, which wander, free from each other, through the liquid, perhaps by successive combinations with solvent molecules in their path. When an electric force is applied, though still moving sometimes in one direction and sometimes in another, the ions on the whole drift in the direction indicated by the force, and we may therefore imagine that two processions of oppositely charged ions pass each other, drifting in opposite directions through the solution. When there is no electric force, the ions are subject to no steady drift, and must move sometimes in one direction, sometimes in another, as the chances of their life direct. Any one ion will sometimes be passing from one solvent molecule to another, carrying its electric charge with it: sometimes it will come across an ion of the opposite kind in such a way that combination occurs, and, for a time, an electrically neutral molecule is formed. By collisions of unusual violence, or by other means, this molecule will soon be dissociated, and its ions again set free from each other, to be handed backwards and forwards by the solvent molecules as already described."

The Nature of a Nerve Impulse. Having framed such a conception, Mr. Whetham shows how it is possible to explain the fashion in which chemical valency and coagulative

power are correlated. A distinguished physiologist, Mr. W. B. Hardy, F.R.S., has shown how electric conditions affect the behaviour of solutions of colloids in water. His results seem to show that colloid particles can exist in solution only when they are electrically charged. If the experiment is so arranged that the charge is neutralised, coagulation immediately occurs. In the case of colloids travelling with the current, it is always the acid ion that causes coagulation, or, in general, it is the ion possessing a charge of opposite kind to that of the colloid particle, and therefore neutralising it, which determines its coagulation. It seems highly probable, not merely, as Mr. Whetham says, "that a wave of this electrolytic coagulation is the physical accompaniment of a nerve impulse," but that it *actually constitutes* the nerve impulse. It need scarcely be said that anything which throws light upon the nature of a nerve impulse is helping us to solve one of the most profound and important problems in all science.

The Nature of a Colloid Solution. It has lately been supposed that the peculiar behaviour of colloids as distinguished from crystalloids in solution is due to the circumstance that colloid solutions are not really solutions at all. It has been supposed that the colloid really exists not truly dissolved in the solvent, but merely in the form of solid particles suspended in it. Particles of quite appreciable size can be detached by various means in some colloidal solutions. The question, however, like most of the others we are considering, is still under discussion. At any rate, it is evident that there is some very marked molecular distinction or inter-molecular distinction between colloids and crystalloids in general. Now, the molecules of colloids are, as a rule, very much larger indeed than those of crystalloids. With this in our minds we may understand the following distinction, as suggested by Mr. Whetham: "It seems likely that the forces which are involved in crystalloid solution are of the nature of those classed as chemical or molecular, while, when colloids dissolve, the actions between solvent and solute are conditioned also by the phenomena studied under the names of capillarity and surface tension. It is not likely that any sharp line of demarcation can be drawn; though as the size of the dissolved particles increases, the importance of the chemical forces probably diminishes, and that of the capillary force grows."

Gaseous Ions. Having discovered the existence of ions in liquid solutions, let us turn and see whether any parallel facts can be detected in gases. Under ordinary conditions, a gas is not a conductor of electricity, and thus the leakage of electricity through the air surrounding a telegraph wire, for instance, is very small indeed. An electroscope, however, will detect an appreciable amount of such leakage. We find, moreover, that under quite a number of different conditions gases can be made capable of conducting electricity in a marked degree. Some of these conditions may be noted.

The mere heating of a gas may cause it to conduct electricity. Recent contact with incandescent metals, the neighbourhood of flames or radium and other radio-active substances, and of glowing carbon, the influence of ultraviolet light bubbling through water, passage over molten phosphorus, the influence of the Röntgen rays or the cathode rays—all of these agencies have the effect of ionising the gas so that it becomes a more or less efficient conductor of electricity. The term ionisation is adopted because we find ourselves justified in supposing that the change in condition of a gas, whereby it becomes a conductor, depends upon the production or presence in it of ions comparable to those first described by Faraday in the case of electrolytic solutions.

What is Gaseous Conductivity? The first fact to recognise is that the ionising agency produces a change in the gas, which persists, more or less, after the agency has been withdrawn. These gases coming from a flame retain their conductivity for several minutes, and furthermore display properties which lead us to suppose that the conductivity of the gas is not a mere state of it, but depends upon the presence in it of material things.

For instance, we find that the conductivity of the gas is a thing that can have its position altered in space. It can be blown about from one place to another. On the other hand, again, it can be filtered from the gas, so to speak, for if we bubble the gas through water or filter it through a plug of glass wool the conductivity is found to have disappeared.

A key to the nature of the something which is present in the conducting gas is afforded by its behaviour nder the influence of an electric field, which destroys its conductivity. We must suppose, then, that the ionised gas contains charged particles perfectly comparable to those which we have already studied in the case of solutions. These must be both positive and negative, since the gas, as a whole, has no electric charge.

Gaseous ions differ in certain ways from the ions of an electrolyte. They have only a brief persistence after the ionising agency is removed. This fact may be explained on the assumption that positive and negative ions soon recombine with one another, and that they also lose their charges by contact with solid bodies around them. The fact that these ions do not persist explains the reason why, in this case, the amount of electric current that can be conveyed is not proportional, as it is in the case of solutions, to the electric force.

The Speed of Gaseous Ions. The speed with which these ions move has been measured in various ways, and is found to be very much higher than in the case of the ions in an electrolytic solution. "At atmospheric pressure, under a potential gradient of one volt per centimetre, the velocities of different ions vary from about three-quarters of a centimetre per second in the case of carbon dioxide to about seven centimetres per second in the case of hydrogen. The velocity of the negative ion is

in general appreciably greater than that of the positive ion, the ratio, unity for carbon dioxide rising to 1·24 for air and oxygen."

The velocity of the positive ions is inversely proportional, as we might expect, to the pressure of the gas. That of the negative ions, however, increases so rapidly as the pressure is decreased that physicists are now led to believe them to possess more complexity of structure at high pressures than at low pressures. This is one of the keys to the nature of these ions.

The Nature of Gaseous Ions. We have already satisfied ourselves as to the nature of the ions in a liquid. In the case of chloride of sodium, for instance, we regarded them as consisting of atoms of sodium and chlorine respectively. But gaseous ions are different. They may be molecular or atomic or sub-atomic; and the conclusion to which we are forced is that the last is the true explanation in the case of the negative ions. The first difficulty was to estimate their dimensions, and the results of the experiments which have been made on this point lead to the conclusion that the normal process of gaseous ionisation consists in the detachment from an atom of gas of a minute particle, called by Professor J. J. Thomson a *corpuscle*. "At extremely low pressures the corpuscle constitutes the negative ion, and the atom or molecule from which it has been separated forms the positive ion. As the pressure rises, neutral molecules become attached to the ions, probably by virtue of the electric forces, and collect round the original ion, which constitutes the nucleus. These complex systems form the ions of gases at atmospheric pressures."

Thus we have reached the admirable result that the negative ions of a gas at low pressures are none other than the corpuscles or electrons of which we have heard so much in this and its companion course. The conclusion is verified when we attempt to estimate the absolute mass of these ions and discover that it corresponds to the mass of electrons as ascertained in other ways.

Large Gaseous Ions. We have seen that at atmospheric pressures and the like ions may be of very considerable size—much larger indeed than molecules. Mr. C. T. R. Wilson, a distinguished worker at the Cavendish Laboratory, has been enabled to demonstrate to the eye the existence of these large ions by means of some very striking experiments. It has long been known that the condensation of drops of water in the air is very greatly aided by the presence of particles of dust, which form nuclei around which the water can condense. What Mr. Wilson did, then, was to obtain air containing an abundance of water vapour, but practically destitute of all dust. In such air sudden cooling consequently yields scarcely any drops of water. Precisely the same conditions, however, yield a dense cloud of drops, which can be readily seen, *if the air has first been ionised*. The explanation of this is that the ionisation has consisted in the production of a number of particles of greater than molecular size which, just like particles of dust, act as nuclei for the condensation of the water vapour. Mr. Wilson's work has enabled Professor Thomson to study the amount of the electric charge upon a gaseous ion. We can measure the current conveyed through a gas, and we know that its amount must depend upon (1) the number of the ions, (2) their velocity, and (3) the quantity of the charge upon each. Mr. Wilson's method enables us to ascertain the number of the ions, and since the other factors can also be estimated the amount of their charge is revealed. It is probably identical with the ionic charge in the case of liquid electrolysis.

Positive Ions. Having recognised the vastly important conclusion that the negative ions of a gas are none other than our old friends the electrons, let us consider more carefully the positive ions. Very striking indeed are some of the fashions in which they can be produced. The mere heating of a platinum wire, for instance, causes it to emit positive ions. These are various in size, some consisting, perhaps, of molecules of the gas surrounding the wire, and some consisting of molecules of platinum. When the wire is made hotter and hotter, however, negative rather than positive ions are given out. In general, low temperature and high pressure favour the production of positive ions, while the reverse conditions favour the production of negative ions.

But platinum is not exceptional in this respect. Other metals behave similarly, and so does sodium vapour. Indeed, *solid electrically-charged matter is given out by all kinds of substances when their temperature is sufficiently high*. Carbon is noteworthy in this respect. These facts are of general physical interest, evidently, but they are also of remarkable interest in relation to some of the greatest of cosmic phenomena. Glowing carbon abounds in the envelope of the sun, and this must constantly emit corpuscles, leaving a positive charge upon the sun. If, then, the temperature of the sun be locally raised, as must undoubtedly often happen, a stream of corpuscles must be rapidly shot out from the sun in all directions. Their impact upon our atmosphere at these high speeds will suffice to make certain of its gases luminous; and this, as we have already briefly noted elsewhere, is thought by Arrhenius to explain the phenomena of the Aurora Borealis.

Electricity in Solids. We have to conceive, then, of the passage of an electric current through liquids and through gases as not a continuous but a particulate affair, the electricity being handed on in units by means of the material motion of the particles composing the liquid or the gas. The same conclusion has to be reached when we consider the passage of electricity through solids; so much the worse, perhaps, for our conventional notion of the constitution of a solid! It is far less solid than we have thought. Indeed, the conduction of electricity through a metal must really be conceived no longer as conduction at all but as *convection*. The reader will remember the contrasting use of these two words in our study of Heat.

Continued

TOOLS FOR MEASUREMENT

Standards. Rules. Surface Plates. Straightedges. Squares. Bevels. Levels. Compasses. Calipers. Gauges. Vernier and Micrometer Instruments

TOOLS
continued from page 4586

By JOSEPH G. HORNER

As in other branches of engineering practice, each great class or group of measuring tool has given birth to numerous variations in form. Rules, calipers, gauges, and the rest, each number scores of kinds, so that exact definition becomes necessary in mentioning any one of these articles. With increasing differentiation and growing complexity the work of manufacture has become highly specialised in the hands of various firms, some of whom now limit their productions to a few kinds of articles only.

The chief difficulties inseparable from the measuring tools are two in number—that of accuracy of manufacture, and that of its preservation in service. These two matters have engaged the best faculties and labours both of mathematicians and mechanics, and the men who measure and test in the shops owe more than they suspect to others who have originated methods of measurement and test, and produced instruments of precision. Few men who handle a pair of gauges at the lathe, or planer, or bench, or who cut a screw thread and measure it with a micrometer or gauge, suspect how much of history lies behind those simple instruments—history which we do not propose to consider. At present we are concerned more with the application of old principles to new tools.

The Main Divisions. The tools used for measurement may be conveniently divided into two very broad groups, in which, as we might suspect, there is some slight overlapping. One includes the tools employed for marking out or settling dimensions directly, with reference to absolute dimensions. To this group belong the rules, scales, compasses, dividers, and allied forms. The other embraces those which are employed for measuring or checking by the contact of rigid parts, possessing a certain degree of known accuracy. In this great group are included all kinds of gauges, besides straightedges, squares, levels, bevels, etc. Some of these are, however, used also for marking out and checking. And the gauges are all derived originally from the absolute measurements of the rule. Thus, one group of measuring instruments is adjustable, while the other is not. In the movable group, dimensions are taken by inspection, and in the fixed group by the sense of touch or contact. This is a most important difference, for although the latter might seem to be the most accurate possible, yet it is not so in fact. It is the most sensitive, but the finest measurements ultimately have to be referred to micrometric divisions, notwithstanding that the sense of touch is capable of detecting differences as minute as any measuring machines will indicate.

There is therefore a fundamental difference between measurements taken by the divisions on a rule and those taken by fixed and unalterable gauges. The first is the older, the second is the modern. The first is lessening, the second grows, until in some departments of modern machine shops a common rule is rarely used or seen. If this rule is employed for some details, it is only for comparatively rough measurements, and not for really accurate work. For no two persons can take a measurement precisely alike with a rule, because the sense of sight alone is trusted, and this is deceptive. He is a very accurate workman who can read within a hundredth part of an inch from a rule, and this is a very coarse dimension. Further, it is obvious that there is very much of measurement which cannot be taken with a rule at all. A rule is adapted for taking a dimension only along a plane external surface. Cylindrical and spherical surfaces, the dimensions of irregular outlines, the mutual coincidence of any portions of work which have to fit one another perfectly, without being tight on the one hand or sloppy on the other; the accuracy of screw threads, and much more of a kindred character cannot be determined with a rule. In all modern workshops, therefore, the tendency is more and more towards the abolition of the rule for all except the very roughest work, and the substitution of various gauges in its place.

Standards. The question of standards does not much concern the workman, although it is of first importance to the manufacturer. We have travelled far since the barleycorn, the cubit, the length of the foot, the handbreadth, and so on were standards suited to the needs of agricultural folks. Accurate measurement became possible only when a national standard of length was fixed, using a bar of metal of a definite material, which had a definit length at a definite temperature. Such is the national British standard preserved in the Houses of Parliament.

The present English standard dates from 1824, when the yard bar made by Bird in 1760 was legalised. But that bar was destroyed by the fire in the Houses of Parliament in 1834, and a new one was made from five existing copies. It is termed "Bronze No. 1," kept in the Houses of Parliament. About forty-four copies were made in bronze and distributed among various public bodies, and these are the standards from which manufacturers have made their own standards for private use. The story of these bars is an interesting chapter in the history of manufacture. Their accuracy at a definite temperature lies within a few millionths of an inch of absolute dimensions. They are never touched for the purpose of making copies from them, and many precautions are taken to prevent alteration in the length, and flexure. The metric standards, which are based upon the supposed length of a ten-millionth part of an arc of the earth's meridian, have no virtue by reason of being based upon a natural measurement, even supposing the length taken were correct, which it is not. There is no need to seek a standard in reference to any natural dimension. The important point is to have a recognised standard which can be easily verified at any time, and this the British standard affords.

But to have such a standard is one thing, its application to the varied requirements of engineers and those engaged in constructive work is another. When the first standard was made a century and a

half ago the methods of measurement in use were utterly crude and coarse by comparison with those of the present day. The 2-ft. rule and the common calipers were the measuring instruments chiefly employed. Those were the days when large screws were cut by chipping and filing, when small ones were cut with solid dies, when cylinders were ground out and not bored, when no standard screw threads were in existence, when there were no planing machines or shapers, no gauges, no milling, or machine grinding, and when $\frac{1}{16}$ in. and $\frac{1}{8}$ in. were fine dimensions.

The era of modern accurate measurement began with Whitworth, but its development has far exceeded anything which his most sanguine visions could have anticipated. Yet in showing that the most refined and accurate measurements must rely on the sense of touch and not on that of sight for their appreciation, and that for definite measurements to be read off they must be read in degrees of revolution of a micrometer screw, he pointed the way to all subsequent improvements in measuring instruments. His plug and ring gauges, and his famous measuring machine embodied these principles, and were the precursors of other contact gauges of special types, and of special measuring instruments, and micrometer calipers.

Intermediate Standards. The methods by which dimensions are transferred from the original standards to the intermediate ones, or copies, are too abstruse for a brief description here. It must suffice to say that no instruments of measurement are ever permitted to be brought into actual contact with the original standards, because that would involve wear. Lengths are therefore transferred by means of microscopic readings from line divisions, and by means of light reflectors from end measures. The intermediate standards which are made and kept for reference in manufactories generally take the form of gauges—that is, instead of having a yard bar, or a metre bar, subdivided into lines, a gauge bar or some one of the numerous types of gauges, each of which gives an end measurement only, estimated by contact and touch, is used. For obvious reasons these are more trustworthy in the hands of workmen than the fine divisions on a standard rule would be, because the former can be *felt*, while in the reading of the latter errors will arise, and a vastly larger time would be occupied in the latter than in the former. When it is necessary to determine exact line measurements in a modern shop, in order either to test a gauge, or to ascertain or to work to an odd dimension for which there is no gauge made, then the micrometer caliper is used for small dimensions, or the measuring machine for larger ones. Each of these types is the offspring of Sir Joseph Whitworth's millionth of an inch measuring machine.

The Rule. We begin our description of the working instruments of measurement with the rule. This is made for reading direct measurements as estimated by the eye, and for taking dimensions from with compasses and similar tools. The forms of rules vary with the requirements of many trades. Those of wood are used chiefly by the woodworking crafts, but metal ones mostly by metal-workers, who are partial to the short rules of 4 in., 6 in., and 12 in. in length, which can be carried in the pocket. Folding rules are not used when very accurate results are desired. The graduations on rules are marked generally, though not invariably, on both sides, and only some of the main divisions of inches are finely subdivided. Large numbers of fine divisions and of fancy divisions are confusing. Only those in frequent use need be given, as
$\frac{1}{32}$ in., $\frac{1}{64}$ in., and $\frac{1}{100}$ in. are less often wanted. A small, separate rule may be kept with these divisions on, and a separate rule for decimal, and for metric divisions. Many rules are made specially narrow to go into confined spaces; others are made flexible to bend round curves. Rules are often combined with squares, the blade being graduated. In doing accurate work measurement should not be taken from the end, because that is subject to wear. It is better to start from one of the inch divisions and read.

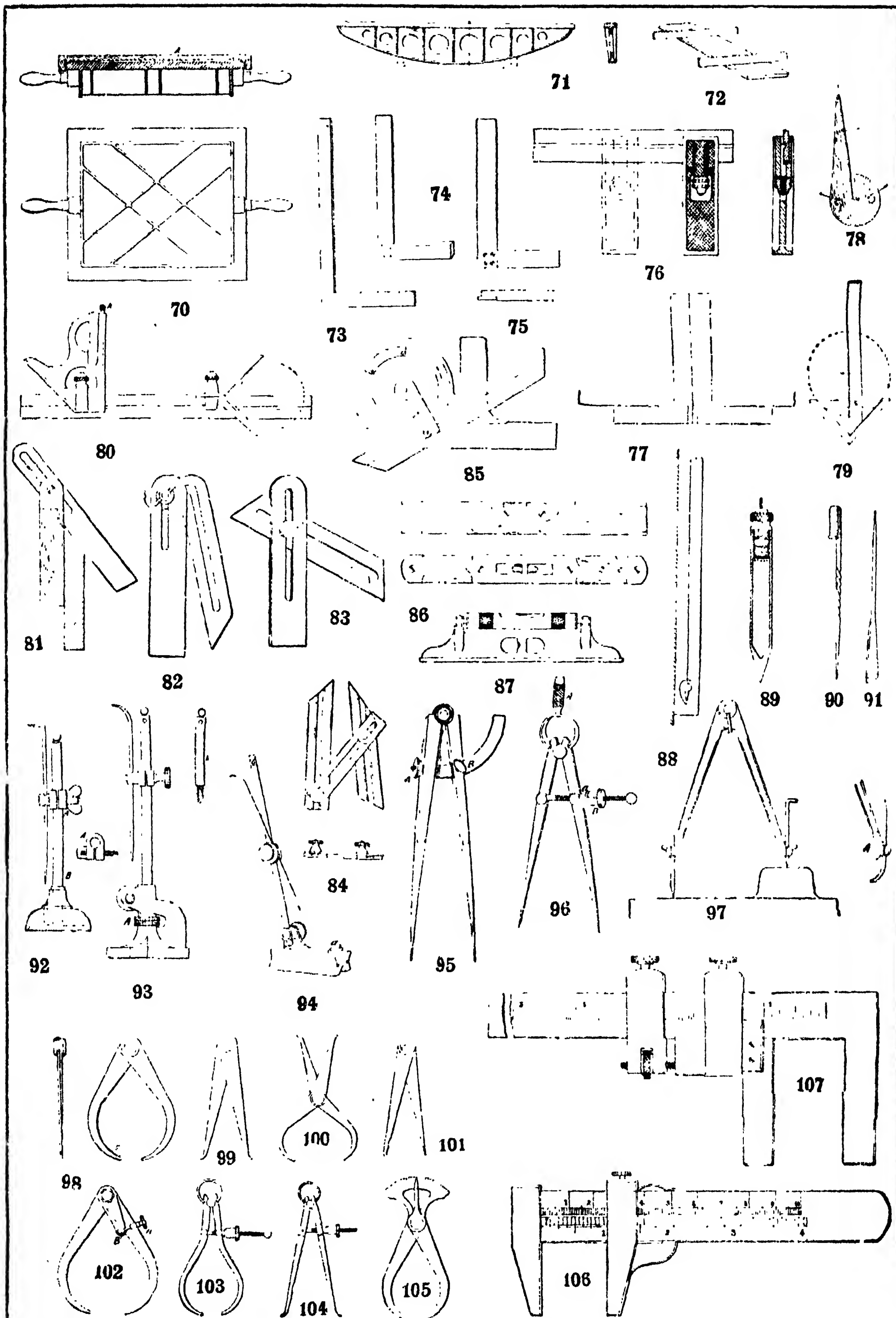
Tapes, Rods, and Scales. Tapes are flexible rules, convenient when lengths of many feet have to be measured. They are indispensable to land surveyors and builders, and to a limited extent are used by engineers for measuring large circumferences and laying out long dimensions. But they are not accurate enough for very precise work, because their length varies with alterations in temperature, and, moreover, they can be stretched by a pull. For accurate lining out, rigid rods of yellow pine, about 2 in. square in section, and properly seasoned, are used and divided off into feet and the coarser subdivisions on a length of from 5 ft. to 10 ft., the ends projecting an inch or two beyond the neat lengths. Then a brass rule, finely divided, is sunk into the first foot division. End measurements are not taken, but only those from the edge, thus the rule never wears. Lengths shorter than the rule may be readily taken, and those of greater length, by moving the rule endwise, with practically no risk. When fine fractional dimensions are required, in these, as in other rules, the reading is taken backwards—that is, from the termination of a 12-in. division which is not finely divided back to the first foot (or, in common short rules, to the first finely-divided inch).

Scales are used for laying out on or taking dimensions from drawings which are made to some proportion less than exact size. They have been described in the course on DRAWING FOR ENGINEERS. They are not used so much in the shops as they were, because now more detailed drawings give views to actual dimensions than was formerly the case. Even when drawings are made to some smaller scale, dimensions are nearly invariably figured on.

The rule is often combined with other instruments which contain provision for contact measurement, as in the slide caliper rules, which will be better illustrated when we consider the forms and uses of calipers.

Surface Plates. There is a large group of tools which are not employed for actual measurement, but for marking and testing the truth of surfaces, centre lines, and edges. This group includes all straightedges, surface plates, squares, bevels, levels, plumb bobs, and allied forms. Though they have this one feature in common, they differ widely in forms.

A plane surface is one of the most difficult figures to produce, and the genius of Whitworth was required to show how alone it can be done. He substituted scraping for the older method of grinding, and showed that in order to originate an accurate surface three surfaces must be mutually corrected. For though it is obviously easy to make one surface coincide with a second one, it does not follow that either is accurate. If No. 1 is concave, No. 2 will be convex, or vice versâ. But if three plates are prepared, and Nos. 2 and 3 are fitted to No. 1, and then No. 2 and 3 to each other, and then No. 1 to Nos. 2 and 3, this process of mutual correction



VARIOUS SMALL TOOLS

70. Surface plate 71. Straightedge 72. Winding strips 73-75. Squares 76. Adjustable square 77. Testing a square 78 and 79. Centre squares 80. Combination set 81-84. Bevels 85. Protractor 86 and 87. Levels 88. Plumb rule 89. Mercury plumb bob 90 and 91. Scribers 92-94. Surface gauges 95. Compasses 96. Dividers 97. Compass with loose legs 98-105. Various calipers 106. Caliper rule 107. Beam caliper

can be continued until all the plates are as true as the limitations of the materials themselves will permit of. The final corrections are extremely minute, and carefully localised, as indicated by the contact of the merest film of oil interposed between the plates. The plates themselves [70] are ribbed to lessen chance of flexure, and are supported on three points only. As in the measuring tools, so in these plates, some are kept only for the correction of the actual working plates, which are distributed about the benches, and all alike are covered [70] A when not in use. These plates are used for testing the truth of surfaces that are required flat, either for bolting up to others, or for sliding. They are often employed as a base for lining out work on, though that is not a legitimate function, because all occasion of unnecessary wear should be avoided.

Straightedges. There is no essential difference in the surface plates and straightedges. The latter must be originated in the same way as the surface plates. But either can be, and is, derived from a standard surface plate known to be true. A straightedge, however thin its edge, has sensible thickness, and therefore its edge must be a true plane, or free from winding. The larger shop straightedges of several feet in length [71] are often two or three inches in width on the edge, and are really narrow surface plates, only the length vastly exceeds the width. These are of cast iron, deeply ribbed, often with feet as shown by dotted lines, and got up by scraping, and are used for scraping large machine slides by and as standards for the production of smaller straightedges. When used for testing the slides of heavy machines the straightedges are held up in the crane-sling, face downwards, and lowered on to the work for trial.

These larger straightedges are generally cambered, as shown, to lessen chance of flexure. But those of moderate and small dimensions are parallel. They are made in metal and in wood. Two parallel straightedges of equal width are *winding strips*, or *parallel* strips [72], and they are used to check the winding of plain surfaces or that non-plane condition in which one or more portions stand higher than others. The value of the winding strips is that, being longer than the width of surface being tested, they magnify the inaccuracies, which are readily seen on sighting along over the top edges.

In testing work with the straightedge, chalk for timber, and red lead in oil for metal are generally used, to show by transference of the chalk or lead from the edge to the face of the work the parts where contact occurs. This contact should be light. Hard pressure and rubbing not only distort, but wear the edges unduly. Also a straightedge should be held vertically, and not tilted at an angle to show the light, which is not a reliable position.

Squares. The numerous squares and bevels are combinations of straightedges, the squares being two straightedges fixed at right angles, the bevels with angles capable of variation. The requirements of mechanics are so extensive that each group includes several designs and sizes.

There are two kinds of squares—the *try*, or *trying square*, formed of two blades at right angles, and the *set* square, the web of which is continuous. The first is used for testing both external and internal angles, chiefly the first: the second for internal angles only. Some try-squares have the *stock* and *blade* of equal thickness [73], but usually the stock, or shorter arm is of greater thickness than the blade [74] as being more convenient in use, the edge of the stock affording a steady, maintaining the blade straight and square across the material. This is sometimes exaggerated by forming a broad flange on the stock, so that the square will stand upright. Being wide, it will not scrape up the sand in foundry moulds, in which work it is specially used.

Variations in trying squares occur chiefly in dimensions, and methods of fitting the blade to the stock. The first have a very wide range, from 2 in. or 3 in. to as many feet. The feature which controls the second in the modern squares is the nature of the provisions for securing the blade and stock. The old plan, and that most common still, is to cut a saw kerf down one end of the stock, insert the blade [74] and rivet it up. But the two cannot be detached again for correction due to wear, nor is it certain that the edge of the blade is pulled up to a good bearing. Hence devices exist for accomplishing both. Blades are screwed in or on their stocks with tapered screws or split screws, which pull the blade against its shoulder, and which may or may not be supplemented by plain screws. In some squares the blade is fitted against an open face [75]. Another provision sometimes made is that for adjusting the blade transversely to its stock [76] which can be appreciated when a blade is too long or too short to go into a recessed situation. A clamping bolt is fitted in the stock, and the blade is grooved to receive the hooked head of the bolt.

A square is tested by setting its stock against an edge known to be true, and by scribing a line on a face coincident with an edge of the blade. If, on reversing the position of the stock, the same edge coincides with this line, the square is true; but if not, then the square is inaccurate by half the amount of difference [77].

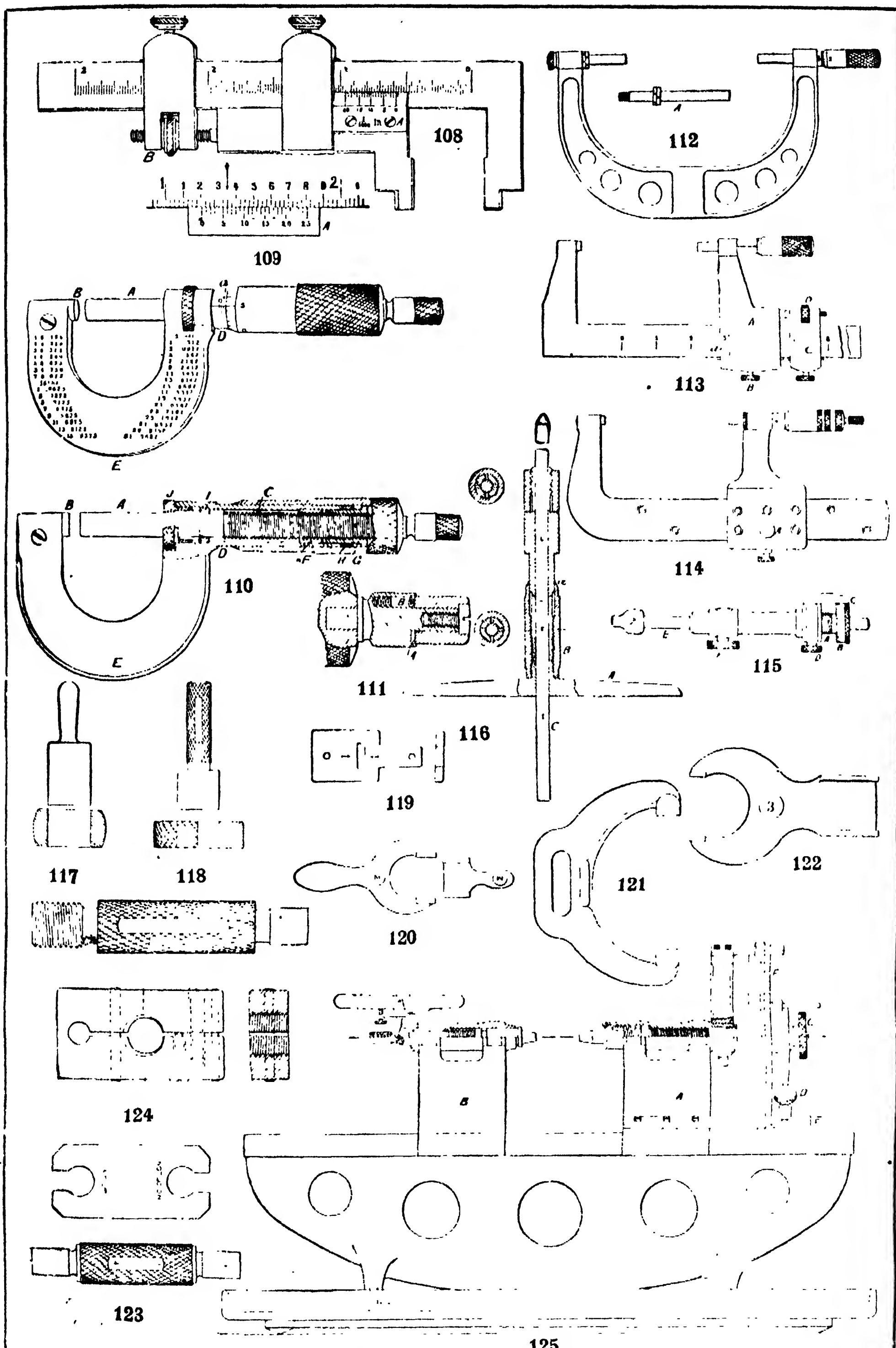
Set Squares. These are always thin, made of wood, or metal, or vulcanite. They are used to test internal angles. A subsidiary utility is that of combining certain common angles between the hypotenuse of the angle and the right angled edges. These are 45 deg., or else 60 deg., and 30 deg. The transparent celluloid squares are useful for the draughtsman, because they permit of seeing lines and figures on the drawing beneath them.

Tee Squares. These differ from the trying squares, in that the stock is prolonged to right and left of the blade, since this type is used only flatwise by draughtsmen against the edge of a board.

Centre Squares. These are squares only in name. The working edge of the blade makes a tangent to any regular arc against which it is laid, and therefore coincides with the centre of the arc, which centre is located by the intersections of lines obtained from two or more settings of the square. These are made of wood, with pins to make contact with the edge of the arc [78], and with metal edges set at angle of 45 deg [79]. In another form, seen to the right in 80, the instrument is made to fit a rule, which thus becomes the blade. The instrument to the left in 80, also clamped to the rule by the same device as that shown in 76, combines a square, a bevel of 45 deg., and a spirit level. A plain scriber is also screwed into the frame at A for use when detached.

Bevels. Bevels are also incorrectly termed *bevel squares*. They are used for laying off and checking angles, which, however, are not marked on the bevels, but obtained from a protractor. They comprise a rigid stock, and an adjustable blade, which is tightened at any angle by means of a screw.

The objection to the common bevel [81] is that in small angles the inner edge of the blade com



GAUGES AND OTHER TOOLS

108. Vernier caliper **109.** Diagram of vernier **110.** Micrometer caliper **111.** Ratchet stop **112.** Horseshoe caliper **113** and **114.** Micrometer beam calipers **115.** Rod gauge **116.** Depth gauge **117** and **118.** Plug and ring gauges **119–122.** Snap gauges **123.** Limit gauges **124.** Screw-thread gauges **125.** Newall measuring machine

so far down the stock that the available length of the blade is much shortened. To remedy this is the reason for the *offset* design [82], in which the available length of the blade is the same at all angles. The long open slot also in the common bevel is objectionable when checking the edges of very thin material, and this is absent in the offset type. In **83** the stock is slotted as well as the blade, so that by moving the latter down the slot, either side of the bevel can be used, which is impossible in **81** or **82**. The combination bevel with three blades [**84**] provides a wider range of utility than the ordinary type. The ends of the blades are also ground to definite angles.

Protractors. These, also termed *bevel protractors*, have the angles set out on the face. The common form is a plated half disc divided round into degrees, from which a bevel is set, or lines marked off directly. But many instruments include a blade adjustable round a graduated plate [**85**] with a vernier reading.

Spirit Levels. These [**86**] are used for testing the general level of surfaces, not in the same sense as surface plate tests, but for setting up a surface known or assumed to be true in a truly horizontal position. They are employed by many trades, but chiefly in the departments of building and engineering.

Levels are mostly short, measuring less than 1 ft. in length. Unless a surface were perfectly true, these lengths would be insufficient to afford a fair test to the general horizontal accuracy of a surface several feet in length. They are therefore laid upon the top edge of a parallel straightedge, long enough to extend over the surface to be levelled, so averaging all slight inequalities. Sometimes the level and straightedge are permanently united, which is a good plan where the work done in a shop is of a uniform character.

Levels used in the ordinary manner wear in time on the base, and so cease to indicate truthfully. Then, if the instrument is turned end for end, the one-sided positions of the bubble must be alike on reversal if the surface is true. But some levels contain provision for adjustment [**87**] to compensate for wear, in the shape of nuts which clamp lugs in which the ends of the bubble tube terminate. The ordinary rigid levels must have their base corrected now and again.

The woodworker uses chiefly levels with wooden stocks [**86**], the metal-worker with those of metal [**87**]. The wooden ones are generally protected with brass plates next the ends. The bubble tube is sunk into the wood and covered with a brass plate with a central bridge. In some metal instruments the tube can be turned round in a casing of brass for protection [**87**]. Many levels have a side sight; the ordinary wooden ones can only be seen by looking down directly on the top. Combination levels are those which have provision for testing the truth of perpendicular faces in addition to horizontal. They contain two bubble tubes at right angles in one stock. Some levels have a vee'd base, which allows them to be used on shafts or tubes.

Plumb Bobs. These are for testing the vertical truth of faces and centres, and depend for their action on the suspension of a pear-shaped weight with a point from a cord. This may be used alone, or in combination with a straightedge, termed a *plumb rule* [**88**]. In one type, a hollow tube with a pointed end is filled with mercury [**89**] which comes to rest quicker than a bob of lead, and is smaller for a given weight.

Marking and Dividing Instruments. Sharp-pointed instruments of various kinds occupy an important place in the work of measurement. These include scribers, surface gauges, compasses, dividers, trammels in various designs, which are constantly being used by mechanics working in wood and in metal. Lines must be *scribed*—that is, scratched or cut, and centres must be pricked or *popped* to be permanent and unobliterated by the usage of the shops, and to be accurate enough to cut by. The finer the lines the better, so long as they are visible, because a thick line has sensible width, which is objectionable.

The Scriber. This is the instrument by which lines are drawn, guided by the edges of squares and straightedges. One end is a point [**90**], the other is often a knife edge [**91**]; **90** is the engineer's scriber, the hook at the opposite end being often made to hang the instrument over the pocket-edge of the trousers; **91** is the form used by woodworkers, the knife edge cutting like a chisel into the wood.

Surface Gauges. Mount a double-ended pointed instrument in a support, and the surface gauge, or *scribing block*, in its crudest form results. For the steady block affords a rigid support to the scriber, and the latter can be adjusted vertically, and traversed along the faces of work, scribing lines as it goes; hence one of the utilities of the marking-out table with its true face. In this way any number of horizontal parallel lines can be scribed at all heights within the range of the surface gauge. All the differences in these tools are matters of detail, differences in plain commonplace tools and those of high precision. These variations consist chiefly in the mere adjustment and pinching of the scriber holder by a thumbscrew, and the employment of finely-pitched or micrometric screws for effecting the adjustments. These take various forms in the hands of different manufacturers, the result being that positive and exact minute dimensions can be obtained by divisions on the instruments themselves. These are a great advance on the old blocks, which had an upright piece, against which was clamped a flat slotted scriber. The scribers are made of round rod in most cases now. Three forms out of many are illustrated in **92**, **93**, and **94**. In **92** the scriber stem is carried in a split lug, A, tightened with a screw and wing nut around the scriber, and on the stem or pillar, B, which is supported on a steady base hollowed underneath to leave an annulus only of bearing surface. This block, in common with others, has a hole in the base to permit of passing the scriber down to form a depth gauge. In **93** a refinement occurs in the form of the milled nut at A, which by means of a finely-threaded screw inside the base affords a fine adjustment to the height of the pillar, and saves troublesome tapping of the scriber to make minute alterations in the height of point. There are several other methods of effecting fine adjustments. Fig. **93**, B is an extension piece for increasing the range of the instrument. A high-class universal gauge is shown in **94**. The stem is pivoted in a lug in a heavy base, so that it can be set in any position between the vertical and horizontal. The base is vee'd to fit circular bodies as well as flat faces. Friction springs retain the stem in position while making adjustments, and also the scriber in its clamping boss. Pins at *a* are fitted to be pushed down below the face of the base; when the base can be slid along the edge of a surface plate to mark lines on a horizontal face. Many scribing blocks have rules fitted, some have a micrometer, making them very precise instruments of measurement.

Dividers, Compasses, and Trammels. These instruments are used both for dividing and for marking arcs of circles. Hence they occur in a large range of dimensions and degrees of precision; from those adjusted by the hands merely and clamped with screws, to those in which the adjustments are micrometric in fineness and precision. In strictness there is no essential difference between the dividers and compasses, because many of the latter combine the finely-threaded screw of the former. But commercially the dividers are classed as those which are opened by a spring, and closed by a wing nut and screw; and compasses are either clamped with a screw pinched on a quadrant or have in addition a fine adjustment or screw; or have neither, comprising legs and hinge only, with or without a clamping screw in the hinge. Thus **95** is a compass, **96** dividers. Fig. **95** is the best form of common compass, because it combines the fine screw adjustment at A in addition to the clamping wing nut at B. The dividers [**96**] differ from the older kinds in having a spring loop separate, and only attached to the legs instead of being in one with them. There is a knurled stem, A, which renders it easier to handle and twirl the instrument than by holding the spring itself. The nut at B is also an improvement on the solid nut, because when the legs are sprung together a little with the left hand the nut frees itself from the thread, and can be slid along instantly, instead of being turned through the whole distance. On releasing the legs, the nut grips the threads again. The nut, B, is like a split chuck, its nose being coned to match a coned ring, *a*. When *a* presses its cone on the nose of A, the latter is compressed inwards sufficiently to engage with the screw threads; when free from the coercion of *a*, its elasticity causes it to open outwards.

Most compasses have rigid legs, but some have also supplementary points [**97**]. The advantage of the latter is that the points, moving in pivoted holders, can be set perpendicularly, however much the legs may be spread, and also that the points may be set in different planes to suit centres or arcs which are not in the same plane. Often these combine calipers with points, being situated at opposite ends [**97**] A, the legs being pivoted to the main legs, still with advantage of perpendicular setting. In other forms this combination exists in the *compass calipers*, or *hermaphrodites*.

Trammels. These are for larger radii and centres than can be obtained with compasses. The trammel heads slide along and are adjusted and clamped on a parallel beam of wood or metal, and designs vary. Some have a fine screw adjustment on one head, some combine provision for inserting a pencil in a tube on one head; but generally two points only and clamping screws are included.

Calipers. The basis of all the contact gauges is the common adjustable caliper, comprising two legs adjustable round the pivot, and capable of taking either external or internal dimensions. The length is then read off on a rule or a gauge. Any common calipers can be used for taking external or internal dimensions. But it is more convenient to have two instruments, the former [**98**] bow-legged to pass over large diameters, the latter [**99**] straight to go into small bores and spaces. These constitute the two types on which modified forms are fashioned, with or without capacity for fine screw adjustment. Sometimes the two instruments are combined in one on opposite sides of a central pivot [**100**], in which case both pairs of points should give the same dimensions. This type is also useful for measuring chambered recesses, the straight legs being passed through and opened out, when the size is measured from the curved legs lying outside; it would otherwise be impossible to record the dimensions, because when the calipers are removed from the chamber, they must be squeezed inwards, and the size is therefore lost. Hermaphrodites, or compass calipers [**101**] are not true calipers, but they have one pointed compass leg and one caliper leg. Their value consists in scribing lines from edges, guided by the caliper leg moved round or along the edges. Centres can also be found when plugs are inserted in rough bores preparatory to marking out for boring, etc.

Calipers of the foregoing forms are adjusted finely by tapping lightly one leg against a rigid body. But others include screw provisions for such adjustments, by which much time is saved. Thus in 102 a fine screw, A, with a knurled head, moves in a nut, B, at the end of the plate attached to the joint. Figs. **103** and **104** are variants on the type of compasses shown in **96**, both in regard to the fitting of the nut to the screw, and in having a spring head. Though in most cases the caliper must be set on a rule or gauge to read the dimension taken, some instruments combine a quadrant rule [**105**], or sometimes a straight rule on the side opposite to the legs, on which the dimensions can be read off. These forms are not popular, but the same principle in other guises—that of the caliper rule and vernier, and micrometer calipers—are largely employed.

The Gauges. Though in the calipers the sense of touch indicates when they are in actual contact with the turned work on opposite sides of its diameter, this device is not an ideal one, because the rule still affords the final test of truth, the calipers being laid directly upon the divisions of the rule in order to determine the size required. This, therefore, is not in strictness a mode of measurement obtained by the sense of touch, since the rule becomes the check, which is of an ocular kind. In order that the system of measurement by touch shall be strictly carried out, the caliper must be checked not on the rule, but against a fixed and rigid standard such as another caliper, or a gauge. To this the objection may be made that it would involve an expensive series of fixed gauges, because the number of dimensions required would be numerous, and this would be true in a degree. The system is expensive in its first inception, but it conduces to such great economies ultimately that all firms who run their shops on modern lines adopt it. The simplest case which occurs is that in which there are two gauges for any one dimension—namely, external and internal—so that while one is used for testing the accuracy of external parts, the other is employed similarly for internal parts which have to correspond. Or if there is no such correspondence, a definite dimension is secured at once, with a degree of precision which cannot be obtained by reference to a rule. Modern systems of measurement are thus both absolute and relative. That is, a dimension may be worked to fractional portions of the inch, or it may be made to correspond with another dimension. In each of these cases the methods followed to-day are essentially those of Whitworth, and though the devices adopted in each case are different, yet the verification in each depends on the sense of touch. To the first or absolute class belong the caliper rules, vernier, and micrometer calipers, to the second the fixed gauges.

But the division into rule measurement and contact measurement is not of a hard and fast character. Many instruments combine the two functions, as the micrometer and vernier calipers.

Caliper Rules. The simplest caliper rules comprise a beam with a fixed jaw at one end [106], and another jaw which can be slid along the beam, and adjusted and clamped to give any width of opening within the range afforded by the length of the beam. The latter is divided out like a rule into English or metric subdivisions, or both. These are sometimes made in wood, but mostly in metal, and fill a useful place in the shops, but they do not admit of measurements of higher precision than the rules do. They simply save the trouble of taking separate measurements, and comprise a caliper grafted on a rule.

A refinement on the caliper rule is the so-called *caliper square* or *beam caliper* [107], which is a stage between the rule and the vernier types, points in which will be noted in connection with the latter.

Vernier Calipers. For very fine measurements the vernier is applied to the caliper rule, or beam caliper, or vernier caliper, producing a most valuable instrument. Its design and construction is shown applied in **108**, and the vernier is enlarged in **109**.

Each inch along the bar or beam is divided into ten parts, and each tenth into four parts, so that each inch has forty divisions. The sliding jaw of the caliper carries the vernier, A, on which a length equal to 24 divisions of the main bar is divided into 25 parts [109], or 20 parts in **108**. Clearly, therefore, each division on the vernier in **109** is shorter than each division on the bar by one twenty-fifth part of the fortieth of an inch, in other words, by ·001 in. When the zero mark on the vernier and the bar coincide, the caliper is set to 1 inch. Any other distance, excepting those at the cardinal divisions, 2 in., 3 in., etc., is taken by the distance to which the zero scale is moved to right or left of the zero on the bar, or the inch divisions on the same. The distance to right and left is counted as the number of divisions the zero point on the vernier has been moved, say, from the zero point on the bar. The number of divisions counted to where one is found that corresponds with one on the bar will be the number of thousandths to be added to the distance read off on the bar itself. Calculation is facilitated by calling the tenths (·100), one hundred thousands, and the fortieths, twenty-five thousandths (·025).

In the illustration [109] the vernier has been moved to the right $1\frac{2}{10}$ in., or 1·20 in. The sixth line of the vernier coincides with a line on the scale (indicated by the arrow), so making $\frac{6}{1000}$, or ·006 in., to be added to the reading from the scale, making the total reading one, and two hundred, and six thousands inches, or 1·206 in.

Around this vernier caliper several designs are evolved. Generally provision is made for fine adjustment of the sliding head by means of a fine screw in a second sliding head, B [108]; also in the beam calipers [107], which is brought up and pinched at a convenient distance away from the head to which the loose caliper jaw is attached. Other devices are used in Continental designs. Many of these calipers are made with compass points on the side opposite to the caliper jaws. Also inside and outside calipers are formed on opposite jaws.

The other great group of calipers, the micrometer type, differs from the vernier in the method of obtaining fine divisions, which involves a different shape.

Micrometer Calipers. In this design the principle is that of the Whitworth measuring machine—namely, the subdivision of the pitch of a finely pitched screw by equal divisions on a circular wheel. Obviously, for a movement of each arc of division on the wheel the screw moves a jaw through a corresponding division of the pitch, which is therefore a definite dimension, however fine it may be. The principle is worked out in a different manner in the micrometer calipers than in the larger measuring machines, and they do not read to so fine dimensions. The following is a description of the Brown and Sharpe micrometer [110], typical in the main of others.

Fig. **110** gives views of the same instrument in external perspective above, in longitudinal section below, with a ratchet stop to the left [111]. The figures on the horseshoe are decimal equivalents, for ready reference. The spindle A is movable to and from the anvil B, and between these the work is measured. A is actuated by the fine screw C. D is the barrel, in one with the horseshoe arm E. The screw fits in a nut, F, which enters a recess in the barrel. A similar threaded nut, G, affords additional support to the screw, and is used to take up wear. It is threaded externally to fit a screw cut in the end of the barrel D, and with one cut in a lock nut, H. The screw threads in G and H are finer than those of the main screw, C, for exact adjustment. A ring, I, encircles the plain spindle A. It has a split tapered boss threaded externally to take the sleeve, J, with a knurled head. This clamps the split boss around the spindle A, locking it after setting. A variation in the position of J is shown in the upper and lower figures.

These calipers measure to $\frac{1}{1000}$ in. The screw has forty threads per inch. The graduations on the barrel, some of which are seen at *a* in the upper figure, in a line parallel with the axis of the screw, are also forty to the inch, beginning at *O*. Each division, therefore, corresponds with the longitudinal distance traversed during one revolution of the screw. The bevelled edge of the thimble adjacent is graduated into 25 parts. As 40×25 equals 1,000, each movement of the thimble round one division advances the screw $\frac{1}{1000}$ in.

Very Fine Measurements. Smaller readings can be taken by estimating by the eye a half or a quarter of a division round the thimble, so that a half or quarter thousandth can be estimated very accurately. But for finer divisions a circular vernier is embodied. It has 10 divisions, which occupy the same space as nine divisions on the thimble. When a line on the thimble coincides with the first line on the vernier, the next two lines differ from each other by one-tenth of the length of a division on the thimble, and so on. Hence, when the thimble is turned so that a line on it coincides with the second line of the vernier, the thimble has moved one-tenth of the length of one of its subdivisions, or $\frac{1000}{10} = \frac{1}{10000}$.

As it is possible to vary the amount of pressure on the instrument, and thus obtain varying readings, a ratchet stop [111] is fitted to some calipers. It is a ratchet, A, with a spring pawl, B. If more pressure is exercised than that which suffices to set the instrument, the ratchet slips past the pawl and stops the further turning of the measuring spindle. When opening, the pawl catches the ratchet and prevents slip.

Variations in this type of caliper by various makers consist in different methods of taking up the wear on the screw for the purpose of re-adjustments after long service, some making it on the

anvil, some on the thimble. Also in the comparative fineness or coarseness of the readings, in the range of dimensions available, and in the graduations in English or metrical dimensions. Other variations are the combination of two calipers in one head for different ranges of dimensions, or for two dimensions nearly alike, as for slack and driving fits. Others are made for special functions only, as for measuring screw threads, wires, tubes, sheet metal, etc. Another distinction is that between small and large types, which involves a difference in design.

Large Micrometer Calipers. The small micrometers do not usually exceed 2 in. maximum capacity, but larger ones are made of horseshoe and beam types for larger dimensions. In these the range of the micrometer screw movement is still small, not exceeding 1 in. usually, but the larger dimensions are obtained by the large size of the horseshoe in the one case, and of the length of the beam in the other, along which a movable head can be set in several positions.

Fig. **112** is a large horseshoe caliper, with a micrometer spindle to the right. The anvil to the left has provision for taking up wear with two ring nuts, and two other anvils (one of which is shown separately at A) are supplied for sizes which the 1 in. range of the micrometer cannot accommodate. The longest anvil would, for instance, measure from 3 in. to 4 in., the next one 4 in. to 5 in., and the shortest 5 in. to 6 in. Beam micrometers are shown in **113**, **114**. The main inch divisions are obtained by clamping the main head, A, with its set-screw, B, by the line on the bevelled edge at *a*. The adjusting block, C, is clamped also near A, in order that the exact setting of A to the inch divisions may be effected by the milled head, D, operating a fine screw. The micrometer then gives parts of the inch.

In **114** the head is set precisely by means of a plug, A, pushed through a hole in both head and beam. The plug is hardened, and the holes are bushed with hardened steel. Each separate hole in the head matches its own in the beam for every inch, thus spreading the total wear over the six holes and simplifying the work of manufacture, since, when a set of plug-holes are lapped out correctly they are done with, and the next holes are treated—a much simpler job than trying to make a single hole in the beam answer for all the settings.

From these leading instruments many others have been derived, or their underlying methods have been grafted on common tools in order to render them instruments of high precision. They include several kinds of depth gauges and rod gauges, which in their crude forms every workman has to make use of in measuring depths below a surface, or diameters of bores, or distances between opposed faces in situations where the common rule or calipers cannot be introduced or would not be suitable. The vernier and the micrometer both appear in these instruments, varied in their methods of application according to the ideas of different firms.

Rod Gauges. Fig **115** is a high-class rod gauge with micrometer readings at the right hand, an immense advance on the gauges made by workmen. The principle is identical with that of the micrometer calipers—namely, a finely-threaded screw, A, and a divided head, B, the graduations of which are read as they pass the arm C. The screw D clamps the setting, if required, by means of a brass anvil pressing on the micrometer screw. To increase the range of the instrument, extension rods, E, are fitted in a socket, and clamped with a screw, F. Other types of these gauges are made with the screw entirely concealed and protected.

Depth Gauges. Fig. **116** is a high-class micrometer depth gauge, which can also be used as a rod gauge on being detached from the foot, A, to which it is screwed, with a hardened contact piece then inserted in the screwed end. This end, B, contains the micrometer screw and the bevelled edge at *a*, the circular divisions corresponding with the thimble in **110**, and reading to thousandths of an inch. The stem or rod, C, is graduated in inches and quarter inches. The sections to the left show the splits for taking up wear.

Fixed Gauges. These all have one feature in common—the embodiment of a rigid unalterable dimension. They occur in numerous forms in cylindrical and flat types, and in various degrees of accuracy, relatively coarse and fine, and in standard and in limit sizes. Some of the most refined mechanical methods are involved in the manufacture of these instruments, including hardening and extremely fine grinding, so that degrees of accuracy range from the coarse $\frac{1}{1000}$ in. to the very fine $\frac{1}{100{,}000}$ in.

Much work in engineers' shops has to be accurate within $\frac{1}{100}$th of an inch, a very great deal within from $\frac{1}{500}$th to $\frac{1}{1000}$th of an inch, and finer. Now, it is easy to observe $\frac{1}{100}$th of an inch by sight alone; it is not possible to estimate $\frac{1}{1000}$th, much less $\frac{1}{10000}$th by the eye. And although $\frac{1}{100}$th is visible to the eye it is not practicable to work to that dimension by setting the rule against the work. In all these fine measurements, therefore, the sense of touch is relied on, and the means used are afforded by gauges ground to precise dimensions required.

Plug and Ring Gauges. In their simplest form these consist of one plug and one ring [**117**, **118**] of the same dimensions. That is, the plug can be just inserted within the ring if a very fine film of oil is interposed without any slackness in fitting. The oil is necessary, because if not applied the one would *seize* or hold so fast within the other that the two could not be separated. Such gauges are termed *standard*, because of exact sizes, as $1\frac{1}{2}$ in., 2 in., or 3 in., no more and no less, within the degree of accuracy mechanically possible.

Now, it is not difficult to see that with these ring and plug gauges absolutely rigid, with no possibility of springing or yielding to pressure, and made to fit each other absolutely, that a piece of tissue-paper, a tangible representation of $\frac{1}{1000}$th part of an inch, could not possibly be inserted between the two gauges, and therefore if work is turned and bored exactly by these gauges, then it will fit within something less than the thickness of the tissue-paper, and that the latter therefore is a coarse dimension.

In one way, however, such gauges might be made to pass work so that there should be two or three times that difference in the thickness of paper. If one gauge were employed at one temperature, and the other at a temperature considerably higher or lower, then when the work should be brought together under normal conditions of temperature, the parts so fitted would not correspond. This at once indicates another element of which consideration must be taken. Then, further, something depends on the nature of the surfaces which are turned, or, when exceedingly fine fitting is concerned, which are ground; whether they are done very smoothly or rather coarsely.

There is another matter which shows how extremely close the fitting of the metallic surfaces can be made. It is quite possible to fit them so well—a plug within a ring—that though they can be slid in while dry, they cannot be separated again. The metallic contact is, in fact, so close that molecular adhesion takes place, and separation must be so forcible that the metal will be striated and torn out by the pressure. But before that occurs the precision of the fitting will have gone past the $\frac{1}{1000}$th part of an inch, with which we started for the purpose of illustration; in fact, as then mentioned, that, though extremely fine if judged by the carpenter's rule, is much exceeded in the engineer's shop, gauges being made to the $\frac{1}{5000}$th part, and the coarser ones to $\frac{1}{2000}$th part of an inch.

Mr. Viall has stated that gauges can be made within a limit of ·00002 in., but makers will not guarantee that they will be within that limit six months after manufacture, since steel changes, "goes and comes." But they can be made and guaranteed to remain for an indefinite period within ·0001 in. He also states that when measuring standard plugs by the aid of the Browne and Sharpe measuring machine, differences of ·00002 in. can be readily felt by those who are not experts in measurement, while by those who are, differences of ·00001 can be readily detected. It is possible to make *working* gauges within a degree of accuracy measured positively by $\frac{1}{30000}$th part of an inch, thirty times less than the thickness of tissue paper! The finest film of gold leaf that floats in the air is about that thickness. Limits of $\frac{1}{50000}$th part are also guaranteed in the best gauges, used for reference.

Limit Gauges. Standard gauges do not measure all the degrees of fitting that are necessary. Thus, for example, the fit of a shaft in the boss of a wheel in which it has to be keyed is a tight, or *driving* fit, or a *force* fit; that is, the shaft must be driven in, or pressed into its bore. But a shaft journal rotating in a bearing must be an easy fit, or a slack or *running* fit, otherwise it would not revolve. But there are also several degrees in slack or running fits, dependent on the classes of work, and ranging from a free fit without any slackness to a fit at the other extreme with $\frac{1}{64}$ in., or $\frac{1}{32}$ in., or even $\frac{1}{16}$ in. of slack. Now, the workmen using standard gauges have to make these various allowances over or under gauge sizes, which results in want of uniformity and some waste of time occupied in making trial fits. This is inconsistent with a system of good fitting, and is impracticable in an interchangeable system. Out of this has arisen the growth of the *limit* or *difference* gauges, in which the *limits*, or *limits of tolerance*, suitable for all classes of manufacture are embodied. These are larger or smaller than standards by the difference required in shafts and their bearings, or in degrees of driving fits. The difference is made in the plug, and not in the ring. Two sizes are generally now made on the ends of one plug, one being a "go in," the other the "not go in," and marked respectively – and +.

Snap Gauges. This term is applied to the flat gauges. These are made in exact fits, and to limits like the plug and ring gauges, and in a range of limits. They also occur in numerous designs—single-ended [119, 120], of horseshoe type [121], and with external and internal gauges at opposite ends of the same bar [122]. The working faces are hardened and ground. Flat and plug limit gauges are shown in 123.

With regard to the difference in the cylindrical and the flat forms, the first named are generally used to check turned and bored work, the ring being slipped over the shaft or spindle, the plug being inserted in the hole of the pulley or wheel. The gauges make contact all round their circumferences, and so check the circular truth as well as diameter, but they cannot be used between two shoulders, such as a journal, the only gauge applicable being one with an open side. For the finest testing the flat gauges give more accurate results, because they have not such large surfaces in contact. This is in harmony with the fact that narrow points are always used in rod gauges. Any width beyond that required for actual contact is superfluous.

The gauge principle, with or without limits, is embodied in other forms, for tapered work, and for testing screw threads, the latter being shown in 124. The upper gauge gives the size of the hole before the thread is cut in it (equivalent to the *tapping size*), and of the thread at the opposite end. The lower tests the screws, and is adjustable by the setting screws to fit the plug accurately, or with a definite amount of slack. The two pins in the body of the gauge prevent lateral twisting of the parts; there is sufficient elasticity in the body to open or close the threaded hole slightly.

Measuring Machines. The basis of all the high-class gauges is found in the measuring machines, which firms keep for testing purposes, and to maintain a check upon gauges in use. Some of these machines are marvellous pieces of mechanism measuring to $\frac{1}{100000}$th part of an inch or less. The famous Whitworth machine, which measured to the $\frac{1}{1000000}$th part of an inch, was the predecessor of later types. The machine had a screw of 20 threads to the inch, which was turned by a worm wheel of 200 teeth, the latter being driven through a worm from a wheel graduated into 250 parts. Hence a movement through one division corresponded to a traverse of $\frac{1}{20} \times \frac{1}{200} \times \frac{1}{250} = \frac{1}{1000000}$th in. This is an example of a machine that does not find scope in practice, but there are plenty of machines measuring to $\frac{1}{100000}$th of an inch. Fig. 125 shows a recent type, made by the Newall Engineering Co. Ltd., Warrington, which measures to $\frac{1}{100000}$th in. The bed carries two heads, A and B, the former having the measuring screw and its disc. As this screw has a traverse of only 1 in., settings must be made from the distances between the heads. Standard end measuring rods are used for this purpose, or a microscope is fitted on the head A to read the graduations on a rule attached to the side of the frame. The screw is rotated quickly by the knurled knob C, or slowly by D, the latter being carried in a rocking lever attached to the screw spindle, and pushed away from a bar, E, by the screw D. The large wheel, F, is divided, and rotates under the indicating bar seen at the top. A compensating device is provided for counteracting the errors in the pitch of the screws, errors which cannot well be eliminated. On the head B a device is fitted which ensures that the end pressure on pieces being measured shall be uniform in all cases. A spirit level is applied in such a manner that it magnifies the movement of the measuring points 4,000 to 1, so that any contraction or expansion of the piece being measured is detected.

Continued

POULTERERS AND GAME DEALERS. The Shop and its Fitting. Buying and Keeping Stock. Game in Season. Prices and Profits

PROVISION MERCHANTS. The Provision Stock. Buying and Selling. Profits. Warranty. Legal Requirements

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POULTERERS AND GAME-DEALERS

In provincial towns the poulterer pure and simple is still to be found in considerable numbers, but in the larger towns and cities, especially of England, he is usually also a cheesemonger, or a fish merchant. In London, for instance, there are probably not more than a dozen men, or firms, who keep open shop solely for the purveying of poultry; but in country towns many good livings are to be made without the cheese, fish, or bacon adjuncts. It follows, therefore, that the conditions of buying and selling—particularly of buying—differ considerably according as the business to be done is in the metropolis or other large centre, or in a country town, with no large central markets like Smithfield and Leadenhall. However, the reader who is interested in this branch of trade may get hints to aid him, whether he purposes starting in the country or in the metropolis. The main idea, however, is to help the man who desires to start in a provincial town or in a suburb to retail poultry and game.

The Primary Essentials. The steps taken to learn the business are simple, but important. There is no regular apprenticeship to the trade. The youth starts his career as errand-boy in the establishment of a poulterer with a good-going business. When not engaged in delivering goods to his employer's customers he is taught how to pluck, clean, and truss fowls, how to skin and clean rabbits and hares, and, generally, how to make the produce ready for the counter. Some men become very expert in plucking—an art not so easy as it looks—nine fowls an hour soon becoming not much of a task for them. Skinning rabbits is much more easily learned, and 100 animals per hour may be skinned by an expert. A period of two years should suffice to teach the lad the elementary principles of the trade, but his experience has to be considerably widened before he can qualify as a poulterer.

Starting Business. Assuming that the young man has acquired an all-round acquaintance with these essentials, and has a capital of about £50 in hand, he may safely embark on his account in a country town, or in a suburb where the necessity for a poulterer and game-dealer is indicated. Of course, in a large city, or in the metropolis, such a capital would be inadequate, provided nothing but poultry and game were intended to be sold. For the business, in London let us say, can be done only in a good-class neighbourhood, where it would be imperative to spend at least three times fifty pounds in fitting-up the shop alone. In the West End, or in any fashionable quarter, the shop of a poulterer has usually elaborate tiled walls and floors, with marble counters and marble window slabs. But the man we have in mind at the moment is the ordinary person with a modest capital and an overwhelming desire to attain to the marble slab stage by honest effort and industry.

Fitting-up. Even in a country town, however, the neighbourhood selected must be a good one. A business thoroughfare, with other good shops in the vicinity, is the place for a shop, and one should endeavour to get a shop which, though not necessarily large, should have plenty of air. A "through draught," although rather trying to the shopkeeper, is a very desirable thing in a poultry shop, for it tends to the preservation of goods which are particularly liable to go "higher" than is desirable if kept for even a short time in a close atmosphere. A lofty, airy shop, with plenty of room in the window should, if possible, be taken, and the fittings required are not a large item. All that is really necessary in this way for a start is a few bars, wooden or steel (wooden for preference), from which the rabbits and hares are suspended. These should be fixed along one side of the shop, while on the opposite side are erected several wooden shelves, on which the fowls, etc., are placed. A counter, a wooden block (for chopping off rabbits' feet, etc.), a chopper, knives, scales, and a spring balance complete the shop paraphernalia, with the exception of a few shelves with hooks screwed into the edges for hanging goods in the window, which ought likewise to have a tiled bottom. The whole of the fittings should cost not more than £15 to £20.

Stock. Of recent years cold storage has revolutionised this as well as other provision trades. Not so many years ago the poulterer depended solely upon home supply for his goods. Nowadays the foreign supply has considerably exceeded the "fresh" in many lines and the foreign trade is growing annually. In a country town even now the main supply of the retailer comes from the surrounding country districts. He buys his poultry and game from the farmers, trappers, gamekeepers, or others authorised to sell game in the neighbourhood, or from gentlemen's estates somewhere within the United Kingdom. But the big towns and cities are now supplied by the foreign game that is shipped daily to the London markets. This foreign produce includes geese, turkeys, and pigeons from France, and fowls from Italy. In the summer season the last-named are sent, chilled, packed in boxes of 12 and 24, but come loose in the winter.

Ptarmigan comes from Norway and from Russia. The country last named also supplies black game, hazel hens, capercailzies, Manchurian partridges, ordinary partridges, and geese, fowls, ducks, and turkeys—all frozen. From Holland wild fowl are obtained; and the Australasian produce includes rabbits, hares, and poultry. America exports to us frozen poultry and game, and, incidentally, our Transatlantic cousins have taught us something regarding the method of packing. The Americans were the pioneers of perfect packing and grading, and their example is now being followed by our own Colonies. Fowls of different grades are packed in wooden boxes, each compartment being made to fit the fowl, so to speak, and not only can the poultry be exhibited with ease, and the minimum of handling, but the weights of each can be depended upon as approximately correct. Canadian turkeys are imported, plucked, graded, and packed in cases of 18 or 24 birds, according to size, tissue paper being placed between the birds and a layer of straw on top. Canada also sends chickens, dressed, to commission merchants in Great Britain and live chickens to importers. Quails are imported in great numbers from Egypt and Algeria, and pheasants and partridges from Austria. Fresh goods are supplied largely to the London markets from Lincolnshire, Cambridgeshire, Norfolk, and from Ireland. A large turkey trade is done with Norfolk.

Laying in Stock. Still keeping in mind the young man with an intimate knowledge of his business and a capital of £50, the question of buying for an opening stock should not be difficult. Knowing the precarious nature of the goods, he would be careful to lay in only a very small stock at first, launching out as he gauged the wants of his neighbourhood. In a country town he would buy direct from the rearers, poultry being bought alive. To start in a small shop his first order would be something like the following. The prices are merely approximate, and vary according to the season of the year and the district.

——	Average Cost.	Average Retail Price.
2 doz. chickens and fowls	£2 to £2 4s.	2s. 3d. to 3s. each
12 pairs rabbits ..	15s.	6d. to 1s. each
½ doz. pigeons (wild)	3s. 6d. to 4s.	10d. to 1s. each
½ doz. ,, (tame)	3s. 6d.	8d. to 1s. 2d. each
½ doz. ducks	10s. 6d. to 12s.	2s. 3d. to 3s. 6d. each
10 doz. eggs	10s. to 20s. (according to season)	1s. to 2s. 6d. per dozen

An enormous trade is now done in Ostend rabbits. These are bought at the London market at from 4s. 4d. to 4s. 8d. per stone of 8 lb. Australian rabbits costing in London from 6¼d. to 6½ each have a large sale in poorer class neighbourhoods at any price from 7½d. to 10d. each. Good English rabbits cost from 8d. to 10d. wholesale, and retail at from about 10d to 1s. 3d., according to size and condition Bordeaux pigeons are shipped to this country in boxes of "sixes," "eights," and "fours." The "fours" are usually large-sized birds and may cost the retailer from 1s. to 1s. 2d. each; the "eights" cost about 1s. 1d., and the "sixes" 10d. each. Eggs are bought in London usually by the 100—120 going to 100. Irish ducks cost usually from 2s. 3d. to 2s. 9d, while good English ducks are dearer—2s. 9d. to 3s. 6d. being average cost. These are naturally finer varieties than the ducks in the table and bear a proportionately greater profit. The fluctuations in price vary greatly, of course, according to the supply and the demand.

Should he happen to open about the Christmas season (which usually lasts from November to the end of February), the retailer would order two dozen turkeys, costing, perhaps, 8d. to 1s. per lb., and selling at 10d. to 1s. 3d., and half a dozen geese, at a cost of 5d. to 6d. per lb., to retail at 8d. to 10d. This takes no account of game, which would perhaps be best left till it was seen how the business was going. Of course, the poulterer in a metropolitan suburb, or a provision merchant who wants to add a poultry department, would simply go to the Leadenhall or Smithfield markets and select his stock from the wholesale merchants there. In such a case he would find that foreign produce is cheaper than the home-fed. For instance, Italian turkeys would not cost more than 6d. to 8d. per lb.; Russian geese would be 4d. to 5d. per lb. and so on; but the quantities mentioned would make a creditable opening in either case. The beginning of November is a good time to start.

Selling Game. As the business seemed to be going all right, the beginner would presently apply for a game-dealer's licence, without which he cannot sell game. To sell poultry (by which is meant pullets, chickens, fowls, ducks and ducklings, geese and goslings, and turkeys), rabbits, woodcock, quail, snipe, or landrail, no licence is required, but to deal in British or foreign game a £2 licence is necessary, annually renewed not later than July 1st. The term "game" includes hares, pheasants, partridges, grouse, and black game. The dealer has also to observe the "close times," and to take care that he does not sell or buy game ten days (one day inclusive, and the other exclusive) from the day on which it becomes unlawful to kill such game. He should note, therefore, that the shooting of game is as follows:

Grouse begin August 12th, end December 10th; partridges begin September 1st, end February 1st; pheasants begin October 1st, end February 1st; wildfowl and landrail begin August 1st, end March 1st; black game begin August 20th, end December 10th. The sale of hares is prohibited from March to the end of July.

The country poulterer would contract for supplies with some gentleman or gentlemen who had estates in his neighbourhood, or somewhere near. The town buyer would get his stock from the recognised markets. The usual wholesale prices are somewhat as follows, with the usual variations in season and supply: Grouse, 4s. to 7s. per brace; pheasants, 1s. 10d. to 5s. per brace; partridges, 2s. to 3s.; hares, 1s. to 3s., according to size. Foreign hares cost from 1s. to 1s. 9d. each; Manchurian

partridges, 10d. to 1s. each; and Russian partridges, 1s. to 1s. 6d. each. The retail prices for grouse vary from 5s. to 8s. 6d.; pheasants, 3s. to 6s. 6d.; partridges, from 2s. 6d. to 3s. 6d.; and hares, from 2s. to 4s. (British), and 1s. 6d. to 2s. 6d. (foreign).

Prices and Profits. The produce mentioned is that in regular sale, and what would preferably be stocked by the beginner. But these by no means exhaust the stock which the poulterer and game-dealer with a large connection requires to keep. As time went on, and the business developed, he would probably have to stock some of the following:

Stock.	Average Cost Price.	Average Retail Price
Blackcock	2s. 3d. each.	3s. to 3s. 6d. each
Grey Hens	1s. 9d.	2s. 6d. to 3s. each
Larks	1s. per dozen	1s. 9d. per dozen
Plovers (golden) ..	10d. each	1s. 3d. each
Plovers (ordinary)	7d. each	10d. each
Ptarmigan	7½d. each	10d. to 1s. each
Snipe	10d. each	1s. 2d. each
Teal	10d. each	1s. 4d. each
Widgeon	10d. to 1s. each	1s. 9d. each

These are mainly for high-class trade, and would be added as required. The business is a fairly profitable one, as will be seen, but allowance must be made for waste, as the stock is perishable. The stock, even in a country business, must be turned over four times a week. The man in the metropolis can keep small stocks, and buy in the markets every day, if necessary. The general and best rule in buying is to pay as you go, and the selling should be for cash as far as is possible. Of course, where credit is given, and in some family businesses it is inevitable, a larger profit must be secured than when cash is paid. The average profit must be about 30 to 40 per cent. on the turnover, and a safe rule is to aim at having a clear profit of not less than 12½ per cent. after paying all expenses.

PROVISION MERCHANTS

Although the provision merchant frequently carries on his separate business, handling bacon, hams, cheese, butter, eggs, margarine, polonies, potted meats, meat pies, sausages, and so on, these goods are also very commonly dealt with by the grocer [see page 3041], occupying one whole side of his shop—the "provision side"—and a separate window. The trade demands considerable knowledge and experience—unless conducted in a very small way—and, indeed, constant daily supplies from a wholesale house, which does practically all the work except the actual retailing. Thus, bacon may be bought ready washed and dried, and pork may be bought in "lengths," pork pies ready-made, and so on. Many a good shop has started in such a small way; but such small shops are hardly to be dignified as provision shops. The provision side of a grocery business, or the provision trade proper, is one in which good profits are made by those who understand their business thoroughly, and are able not only to sell, but to buy well, taking advantage of the frequent and rapid turns of the market; but as the market fluctuations cut both ways, there are few retail businesses in which so much risk is run by the inexperienced or where money is so quickly lost. Within the last three or four years prices of bacon and cheese have been ruling abnormally high, and profits have been difficult to secure.

Starting in Business. As regards capital, selection of shop, etc., the general remarks under the head of Grocery will apply, and it is unlikely perhaps that a novice will start in the provision trade without grocery, although he may certainly do well to give the former side of his business special attention and prominence if there is a promising opening in the neighbourhood he has selected for his venture.

Arrangement of Shop. The provision side and window should be that which gets least sun. Given this condition, it is often found convenient to allot the right side of the shop to provision, and the left to grocery. The "Practical Grocer" gives the following details of a "provision fitting" for a shop. "The provision fitting would be, say, 12 ft. long, 18 in. deep at bottom, and 11 in. above counter height. The fitting would have a marble counter shelf 18 in. wide, and under same would be fitted uprights and shelves, with spaces for eggs, etc. Above the counter shelf the wall would be lined to a height of 2 ft. with marble, or an imitation tile (on zinc) can be executed at much lower cost. The centre of the fitting would be provided with two iron bars and two hangers for hanging sides of bacon upon. At each side of the centre would be provided three shelves for tinned goods, and a moulded cornice, and the whole hung up to ceiling above on iron rods. From the end of the provision fitting to the end of the shop would be provided a fitting for Italian goods, jams, pickles, sauces, etc. This fitting would be 12 ft. long, 18 in. deep at counter height, and 11 in. above. The lower part of this fitting could be used for other goods. Across the back of the shop would be provided a fitting with shelves and lockers for sundries."

The *provision window* usually has a marble bed, and a common plan is to have a marble shelf about 8 in. wide placed at the back of the window, with a mirror at the side. The window may have sliding sashes, so that it can be dressed from outside if desired. A light, decorated iron frame with marble shelves may be put in the middle and circular stands at the sides, with porcelain stands for "pure butter" and "margarine" respectively, and art-coloured majolica pedestals and pots for palms or ferns to give a cool and fresh effect.

Storage. A good cellar, dry, cool, and well ventilated, is very necessary. Refrigerators or ice-boxes are also useful. They are much used in America, for instance, on account of the heat. To keep butter free from dust and fresh there is nothing better than boxing in the butter stand completely with plate-glass fixed on the counter. Sparkling glass, polished marble, etc., have much to do with making a shop attractive to the customer. The window should be dressed thoroughly and attractively every morning. Cleanliness everywhere is, of course, essential

in a provision shop. Cheese should be stored in a cool cellar, on shelves specially made for the purpose, as it is necessary to turn them over occasionally to prevent cracking and "sweating." Bacon needs unceasing vigilance, especially in summer. A place with plenty of good ventilation is best for storing bacon. It should be bought once a week, if possible, as much of it is mild-cured nowadays, and a quick sale is required. Fresh eggs should be kept in a dry, cool place, free from any odour which would be capable of impairing their flavour.

Treatment of Stock. In the profitable handling of provisions, unremitting care and minute attention to detail are essential. Be careful *always* to avoid overstocking, which means certain loss from shrinkage and deterioration. All goods should be weighed, checked, or counted when received, and claims promptly made for damages. Eggs, for example, are a very common subject for claims upon railway companies. Eggs may be tested for freshness in various ways. In the Paris markets eggs are tested by means of a glass of brine made by dissolving common salt in water in the proportion of a pint to each 2 oz. of salt. An egg to be tested is dropped into the glass. If perfectly new laid, it sinks to the bottom; if more than a day old, it does not rest on the bottom; if five days old, it floats. In this country the wholesale method of testing eggs is by what is called "candling." A box is arranged so as to exclude light, excepting a strong light thrown through the eggs under examination by means of a lamp. The light thus projects an illuminated image of the egg upon a mirror, wherein a fresh egg appears unclouded, while a bad one shows a dark spot; the larger the spot the older the egg. Eggs that have been preserved, as eggs now frequently are, by means of a solution of water-glass, should always be examined thus before being sold. If a proper candling lamp is not available, one may be constructed by cutting an oval hole, the size of an egg, in a piece of black cardboard nearly a foot square. Place the egg against the hole, and look through it at a strong light. If the egg be dark or show spots, it should be rejected. In unpacking eggs, sort them out into small, medium, and large, and price accordingly.

Butter. In buying butter, Danish rules the market, though Normandy and Brittany take first rank for fresh in London and the South of England. Irish has greatly improved, and fine grades run the Danish close, and, it is to be hoped, will at no distant date excel it, in the English market. But the Danes have managed their trade remarkably well, and excel in uniformity and regularity, while no expense is spared in ensuring rapid transportation and delivery in the markets here. Some English farm butter is excellent, but the supply is so badly regulated that, as a rule, it does not count. In contracting for Danish, it is by no means uncommon to agree to pay the wholesale agent a fixed sum per cwt. over the current Copenhagen quotation, this quotation being fixed officially every Thursday, and regularly published in the current trade papers. The Copenhagen Committee have now arranged, since March 29th, 1906, that the quotation shall include the "overprice," so as to avoid the confusion which previously arose. Bacon, eggs, etc., are sold wholesale subject to specified conditions of sale fixed by the wholesale associations. Of these conditions the retail buyer should inform himself by studying the trade annuals.

Handling Provisions. The following miscellaneous hints on handling provisions are practical. In cutting up bacon, avoid accumulating bits; bad cutting by inexperienced hands will prove detrimental. Weigh closely and reckon correctly. Best cuts command ready sale at profitable prices; make ends or unsaleable cuts low to clear. Label hams with weight, and price directly on receipt with both bacon and hams, work out cost and profit occasionally by actual "results"; it is astonishing how often these are different from what is looked for. Cheese and butter should also be tested for shrinkages and estimated accordingly. Do not have too much cheese in cut at a time, or dryness and deterioration will be the consequences; a fresh appearance is the best salesman. Take tastings from the inside of a wedge. Butter should be kept as fresh and firm as possible. A speciality should be made with butters of finest quality, and they should be sent out in nicely worked-up rolls and prints. Keep cut lard neatly wrapped in parchment covering, according to requirements; this prevents loss from hasty weighing. Avoid sending out bad or broken eggs. Cooked hams, pork pies, sausages, etc., are profitable side lines if quick sales can be effected; otherwise they are best left alone. Ticket everything, and sell at marked prices only. Take stock often, advertise judiciously, endeavour to obtain your customers' confidence, and a good paying provision trade is assured.

Warranties: Water in Butter. While the law specially affecting the sale of provisions is dealt with below, it is necessary to point out here that in purchasing provisions great care is needed. The Board of Agriculture is empowered by the Sale of Food and Drugs Acts to fix authoritatively the quantity of moisture permissible in butter, and has decreed (1905) that not more than 16 per cent. shall be allowed unless the excess is declared to the purchaser. Consequently it is necessary that the retailer be on his guard against buying butter with more than 16 per cent. of water. A simple method of estimating the percentage of water in butter is practised in the Cork and Limerick markets, and is accurate enough for practical purposes, although, of course, it is not a proper analysis. It requires only a small saucer-shaped vessel, a small spirit or gas lamp, and a cheap set of scales and weights such as apothecaries use. A piece of butter is weighed and then heated in the saucer over the lamp for a few minutes, with constant stirring, until no more steam is observed to arise from it. After being allowed to cool, the butter is weighed again, and the loss of weight shown gives the amount of water which was in the butter. A specific warranty should always be obtained when buying butter.

also for cheese, lard, and margarine. It is the law that not more than 10 per cent. of butter fat shall be found in margarine. To any warranty the signature or initials of the guarantors must be appended.

Staff. Provision hands receive about the same wages as first grocery hands, and should be the best and most experienced men available in a shop. In engaging a manager for a shop where margarine is sold it is not unusual to stipulate by signed agreement that he shall respect and observe all the requirements and provisions of the Margarine Act, and sometimes that he will indemnify the employer against penalites or losses occasioned by neglect or irregularity in exposing for sale or retailing margarine. Some employers direct in their shop rules that margarine and cheese shall be "ironed," or tested by the managers as to their quality before being placed on the counter for sale, and that the butterman shall frequently wipe the provision scale plate to keep it free from water and scrupulously clean. It is forbidden to re-wrap margarine on the provision side after it has been sold in the legally prescribed wrapper; if a customer wants it wrapped again so as to hide the label, she is asked to take it across the shop to the grocery counter and have it done there.

Profits. A provision merchant who analyses results in his various business departments gives the following as gross profits: Bacon, 11 per cent. profit, and stock turned over at least every fortnight, or twenty-six times in a year; hams, 13 per cent., but turned over twelve times only; cheese, 12 per cent., stock turned over eight or ten times (cheese profit is usually higher than this); salt butter, 10 or 12 per cent., turned over twelve to twenty times; fresh butter, about 12 per cent., stock turned over nearly twenty times; tinned meats, 15 per cent., but turned over four to six times, which, however, is not so frequent as it ought to be.

Laws as to the Sale of Provisions. The Sale of Food and Drugs Acts, the Margarine Act, and the Merchandise Marks Act impose very special liabilities on the retailer who deals in provisions and demand therefore his careful study and observance. The prejudice caused in the minds of his customers by a conviction under these Acts is usually greater loss than the actual penalty. To deal with the last-named Act first, it is under the Merchandise Marks Act that traders have been prosecuted for selling ham not from Scottish pigs as "Scotch hams," and bacon not bred in Wiltshire as "Wiltshire bacon." In the trade "Wiltshire cut" appears to be thought allowable, but bacon that is not cured in the Wiltshire district must not be sold as "Wiltshire," or trouble is sure to follow. The offences defined by the Act are applying to goods "any false description," or having in one's possession for sale any goods to which any forged trade-mark or false trade description is applied; and the expression "false trade description" means a trade description which is false in a material respect as regards the goods to which it is applied. The Food and Drugs Act and the Margarine Act apply mainly to the provision dealer because of the great amount of adulteration that has in the past prevailed in butter. The main forms of such adulteration are the admixture with butter of margarine, the wilful addition of water beyond the legal or the natural quantity, and the admixture of neutral fatty substances such as coconut oil. Cheese also is liable to be adulterated, or rather, imitated, "filled" cheese having become so common in the trade that it had to be dealt with specially by the Sale of Food and Drugs Act, 1899, under which it must now be sold as "margarine cheese."

What is "Food"? This enactment expressly declares that "for the purposes of the Sale of Food and Drugs Acts, the expression "food" shall include every article used for food or drink by man, other than drugs or water, and any article which ordinarily enters into or is used in the composition or preparation of human food, and shall also include flavouring matters and condiments." Under the previous Act of 1875 some foods, etc, escaped the law—egg powder and baking powder, for instance, which are now covered. The main sections of these important Acts seek to protect the food of the people by prohibiting the mixing of injurious ingredients with food; prohibiting the sale of articles of food not of the proper nature, substance, and quality; prohibiting the abstraction of any part of an article of food before sale and selling such without notice to the purchaser; defining butter, margarine, and margarine cheese and regulating their sale; empowering the authorities to examine at the ports and elsewhere and take samples of analysis, and so on. Section 3 of the Act of 1875 enacts that "no person shall mix, colour, stain, or powder, or order or permit any other person to mix, colour, stain, or powder, any article of food with any ingredient or material so as to render the article injurious to health," and no person shall sell any such article, under a penalty not exceeding £50, thus regulating the use of preservatives and colouring matters such as copper in tinned peas and boric acid in milk and butter. If a retailer is summoned under the section mentioned he can escape by proving that he did not know that the article was injurious to health, and could not with reasonable diligence have obtained that knowledge. Section 6 of the same Act, the principle one under which proceedings for adulteration are taken, directs that "no person shall sell to the prejudice of the purchaser any article of food or any drug which is not of the nature, substance, and quality of the article demanded by such purchaser, under a penalty not exceeding £20."

What is Permitted. No offence is committed (1) where any ingredient not injurious to health has been added because required for the production or preparation thereof as an article of commerce in a state fit for carriage or consumption and not fraudulently to increase the bulk, weight, or measure of the food or drug, or conceal the inferior quality thereof; (2) where the drug or food

is a proprietary medicine or the subject of a patent in force, and is supplied in the state required by the specification of the patent; (3) where the food or drug is a compounded medical prescription; and (4) where the food or drug is "unavoidably mixed with some extraneous matter in the process of collection or preparation." Either the employer or the assistant may be summoned and fined under this Section 6, but there is an important protecting section which declares that there is no offence in selling an article of food mixed with any matter or ingredient not injurious to health, and not intended fraudulently to increase its bulk, weight, or measure, or conceal its inferior quality, "if at the time of delivering such article or drug he shall supply to the person receiving the same a notice, by a label distinctly and legibly written or printed on or with the article or drug, to the effect that the same is mixed."

Butter. It might be supposed that this would apply to butter, the "bulk" of which is increased by the addition of water or milk; but such butter is (1905) allowed to be sold in shops where the fact of such admixture of milk is brought to the purchasers' knowledge by notice, just as diluted whisky or milk is, on the strength of ruling by the High Court that a sale cannot be to the "prejudice of the purchaser" under Section 6 where the seller brings to the purchaser's knowledge the fact that the article sold is not of the nature, substance, or quality he demands.

"If," said the Court, "the alteration is brought to the knowledge of the purchaser, and he chooses to purchase notwithstanding, it can never have been intended that such a transaction should be interfered with." It is questionable if the public generally realises that the butter is not pure, but the merchant who puts up his ticket with "milk-blended" butter will probably explain as seldom as possible. You can bring the alteration to the purchaser's knowledge in any way you please so long as you do it in some way; and this is why, in some hotel bars the legend may be read: "All spirits sold here are mixed." The same protection applies to goods such as butter or milk. When margarine is sold, that fact must be conveyed to the purchaser's knowledge by wrapping it in a special wrapper, prescribed by the Margarine Act and the Sale of Food Act, 1899; but if margarine is supplied when "butter" has been asked for it is necessary also to give the customer a verbal intimation.

The Margarine Act. The Margarine Act defines as "butter" the "substance usually known as butter, made exclusively from milk or cream, or both, with or without salt or other preservative, and with or without the addition of colouring matter." As already mentioned, the Board of Agriculture, which is empowered to fix standards, has added to this that butter shall not contain more than 16 per cent. of water if it is to be presumed genuine. The Act then declares that "the word 'margarine' shall mean all substances, whether compounds or otherwise, prepared in imitation of butter, and whether mixed with butter or not, and no such substance shall be lawfully sold, except under the name of margarine, and under the conditions set forth in this Act." To this definition the Food and Drugs Act, 1899, added that margarine containing more than 10 per cent. of butter fat shall not be sold at all—the object being to prevent the sale of those "mixtures" that are peculiarly liable to be passed off as butter. This latter Act also defines as margarine-cheese "any substance, whether compound or otherwise, which is prepared in imitation of cheese, and which contains fat not derived from milk"; and this article, margarine cheese, has to be sold under the same conditions as margarine.

Selling Margarine. The retail dealer who exposes margarine for sale must attach "to each parcel thereof so exposed, and in such manner as to be clearly visible to the purchaser, a label marked in printed capital letters, not less than one-and-a-half inches square, 'Margarine.'" It is also best to place the lump or lumps of margarine so exposed for sale on a slab bearing the word "Margarine." Then, when handing margarine to a customer the retailer must be careful that it is in a paper wrapper on which is printed the word "Margarine" in capital block letters, not less than half an inch long, and distinctly legible, and with no other printed matter appearing on the wrapper. In the same way "margarine cheese" must appear solely on the wrapper of imitation cheese. Condensed, skimmed, or separated milk must be labelled "machine-skimmed milk." Under the Margarine Act an invoice is a warranty, so that if the provision dealer has bought what he believed to be butter, and it is called "butter" (not "Danish" or "Irish" merely), on the invoice, the production of this invoice will exonerate him if the substances prove not to be genuine.

Continued

CONDIMENTS

Sources and Manufacture of Salt. The Salt Mines of England. Uses of Salt. Vinegar. Pepper. Mustard. Ginger. Spices

Continued from page 4569

By CLAYTON BEADLE and HENRY P. STEVENS

ALTHOUGH eaten with foods, condiments cannot be regarded as true foods, as their food value is almost negligible, many (such as pepper, mustard, and spices) being largely composed of indigestible fibre. They may, however, be regarded as adjuncts to food, and are taken in comparatively small quantities, with the idea of stimulating the appetite. Most of them contain a small proportion of a very active ingredient. Thus pepper contains a resin, "piperin"; mustard, a volatile oil; and spices similar oils, which give to the condiments their peculiar flavours. These active ingredients are so powerful that they would act as poisons if taken in really large quantities. Acetic acid, too, can only be taken in the diluted form as vinegar. In virtue of the chemical nature of the active ingredients, many condiments act as food preservatives, especially salt and the spices.

Common Salt. Although most condiments can hardly be regarded as necessities, common salt is certainly an exception. It is one of the essentials for our health preservation.

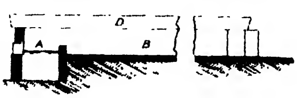
Nature has endowed this country with salt supplies second to none, both in quantity and quality. Salt is brought to the surface either in the form of clear liquid, as *brine*, or as dry rock, known as *rock salt*. Cheshire brine yields for every imperial gallon 3 lb. 2 oz. of dry salt. Roughly, 1,000 gallons of brine produce 1 ton of dry salt.

The brine is said to run under the earth in channels, and to collect in the lowest part of the geological basin at a depth of about 130 ft., whence it is pumped to the surface. It is supposed to result from the rainwater percolating to the rock salt and dissolving it. Where fresh water reaches the surface of rock salt, either at the outcrop or through fissures in the outlying marl, brine is formed

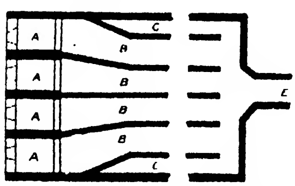
The brine has the following average composition:

Substances	Northwich.	Droitwich.	Stoke Prior.
	Per cent.	Per cent.	Per cent.
Sodium chloride ..	25·222	22·452	25·492
Calcium sulphate ..	·391	·387	·261
Sodium sulphate ..	·146	·390	·594
Magnesium carbonate	·107	·034	·034
Total solids ..	25·866	23·263	26·381

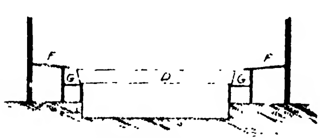
Brine is pumped by two plungers from a depth of 64 yards through an 8-in. pipe, and delivered to an enormous wooden cistern measuring about 36 ft. by 32 ft. by 10 ft. deep. From this tank the brine passes through pipes to the evaporating pans.



1. SETTING OF SALT-PANS (Longitudinal section)



2. PLAN OF FLUES OF SALT-PAN



3. TRANSVERSE SECTION OF SALT-PAN



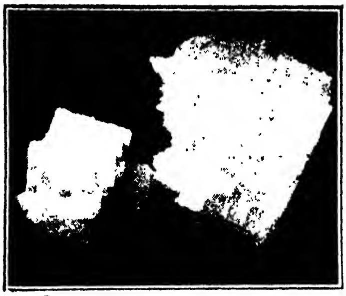
4. RAKE 5. SKIMMER 6. MOULD

The Salt-pans. The pans are made of steel, measuring about 36 ft. by 24 ft. by 20 in. deep, rest on brickwork, and are heated underneath by coal fires. A battery usually contains from five to ten pans. For examples of ordinary pan settings, see **1, 2,** and **3**. This type of pan has one flue, B, for each fireplace, A, and blank places, C, over which the salt in the pan can be scraped to the side without fear of overheating. D is the salt-pan, and E the flue to drying-room; F F the hurdles, and G the floor, on which the workman stands. Each pan in the particular works we are describing has two fires, divided by a partition wall running halfway to the back of the pan. In order to ensure even distribution of heat, there are five draughts, as they are called, divided by four parallel walls running halfway from the back. Brine is conveyed continuously to the evaporating pan, gentle ebullition takes place, and enormous volumes of steam pass off from the surface and disappear up the ventilators in the roof. The temperature of the brine is maintained at about 220° F.

As the water evaporates, an incrustation of crystalline salt is formed on the surface, which, as it gets heavy, settles in the cooler end of the pan. The crystalline deposit of pure salt so formed is drawn to the side of the pan by means of a rake [**4**]. The salt is then lifted out of the pan by means of a skimmer [**5**], a perforated scoop about 18 in. diameter. The excess of liquid drains through the perforations and the contents of the skimmer are transferred to a wooden mould consisting of an open box [**6**] tapering from one end to the other (length, 22 in. and 8 in. by 8 in. at large end), standing on its smaller end.

Drying and Packing the Salt. When a number of moulds have been filled and allowed to set, they are inverted, tipped out, and conveyed to the drying-room. The ordinary size block weighs 28 lb. (80 to the ton). Each pan produces 4 tons in 12 hours (equal to about 50 tons a week).

The drying-room is heated by the waste heat from the furnaces, which passes through long, square, iron flues, 4 ft. by 4 ft., placed on the floor level, on and around which the blocks are stacked. The temperature of the drying-room varies from 120° F. to 150° F. The blocks take six to fourteen days to dry, according to the temperature and weather. The dried blocks now pass through a munching machine, and then through a pair of rollers, and finally through sieves, until the required grain of salt is obtained.



7. BAY SALT (One-third scale)

The dry salt is carried by "elevators" to the top of the building, whence radiate, octopus-like, shoots or feeders, reaching to all parts of a large packing-room where girls are busily employed filling *damp*-proof paper packets, which consist of two sizes, and contain 1½ lb. and ¾ lb. respectively of table salt. This is never touched by hand from beginning to end.

Preparing Fishery Salt. The preparation of salt for the preservation of food, such as fish salt, is made somewhat differently from that of table salt. It has to be coarse and distinctly granular for sprinkling between layers of fish in boxes or barrels, as, if too fine, it would melt too rapidly.

For *fishery* salt, the brine in the pans is evaporated at from 90° F. to 120° F., according to the quality to be produced. The lower the temperature the coarser the grain, and the slower the operation.

There are several qualities of fishery salt, distinguished according to coarseness. The first grade of salt is named Second Fishery, a degree coarser is Best Fishery; next higher grade is X Fishery, a still better quality is XX, and the highest of all, and the coarsest, is Bay Salt [7].

From 22 to 25 tons per pan per week is the average production of fishery salt.

8. ROCK SALT FROM ADELAIDE MINES (One-third scale)

The Salt Union supplies 90 per cent. of the salt used in Great Britain for fish-curing. The pans owned by them have a capacity of about 1,000,000 tons per annum. The attempt to oust the pure natural article by salts obtained from sea-water evaporated by the sun's rays in hot climates is likely to end in failure, as, in addition to the great inferiority in composition of the latter, there is a liability to the formation of a fungus on fish which does not take place with the pure article. Sea-water also contains many organic ingredients that militate against the proper preservative action of salt.

The following analysis will show the difference in composition between the Cheshire fishery salt and the foreign sun-evaporated sea-water:

Ingredients	Cheshire Second Fishery	Foreign
	Per cent.	Per cent.
Chloride of Sodium (pure salt)	97·32	89·21
Moisture	1·72	[illegible]·82
Sulphate of lime	·85	1·48
Sulphate of magnesium ..	·—	3·15
Chloride of magnesium ..	·08	·95
Insoluble matter	·03	·39
	100·00	100·00

Where Rock Salt is Found. The geological position of rock salt occurs between the coal formation and the lias in the new red sandstone of the Triassic series. The great rock salt formation of England occurs within the red marl, or red sandstone. At Northwich, in the valley of the Weaver, rock salt is found in two chief beds, the top being about 87 ft. thick, and the bottom 90 ft. The top bed is 126 ft. below the surface.

The mining is done from the bottom of the layer of the thick bottom bed, where the best salt is found. The natural beds are about 2 miles long by 1½ miles wide.

A Large Salt Mine. To support the weight above, it is necessary to leave pillars of salt equal to about one-twelfth the area of the mine. This is done by leaving enormous pillars (somewhat larger at the bottom than the top), 10 yd. square and 25 yd. apart.

The rock salt raised as blasted from the Adelaide mines belonging to the Salt Union, Ltd., at Marston, Northwich, is called "Prussian Rock," when brought to the surface, and the larger pieces resemble enormous blocks of granite and porphyry. In places it contains veins of deep brown or amber colour [light portions, 8], grading to pale transparent salmon tint [dark portion, 8] and in some parts it is as transparent as glass and very pure, and crystallised in large cubes [9]. If taken at base of vein, one occasionally finds attached pieces of stone [see right-hand bottom corner of 10]. In other places the caverns are bristling with needle-shaped crystals not unlike the familiar sal-ammoniac [11], and in some few places it is opaque and white, falling to pieces between the fingers as though Nature had already prepared it for coarse fishery salt [12]. The mine at Marston is 336 ft. deep. It is approached by a perpendicular shaft about 9 ft. wide by means of a bucket which emerges into a cavern 30 ft. high. This cavern is the largest rock mine in Great Britain. Its walls and domes are bristling with crystals of rock salt in the various varieties referred to above. This chasm has entirely resulted from the removal of enormous quantities of salt rock, about and around which there still exist almost limitless supplies.

The Mining of Rock Salt. In order to obtain the rock salt a horizontal incision is made in the wall of the rock 7 in. from the base, the incision being 4 in. deep and 28 in. wide. This is performed by a machine resembling a very substantial circular saw with two-way teeth arranged

9. SALT CRYSTAL FROM ADELAIDE MINES (One-half scale

round its circumference. The machine is driven by compressed air laid on to the mine, and is moved forward by means of a grab. The cut is made slightly downwards so that the floor appears in ridges. The progress of the work depends largely upon the hardness of the rock, which varies considerably at different points. To prepare the rock to receive the charges for blasting, holes are produced by means of an iron pole called a *chisel*, that is rod-shaped and tapering towards the end, which is beaten out to a spear-shaped head. This is thrust into the rock and turned until the required depth is reached. In this hole a charge is inserted and fired by the aid of a fuse. Sometimes the charges merely crack the rock and at others they remove several tons. Thus, if large pieces are wanted, a small charge is put in vertically by which the face of the rock is just cracked and the necessary sizes are removed with a pick. If small lumps are required, a large charge is put in in a slanting direction, which blows the face of the rock to pieces.

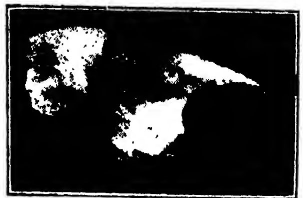
In addition to their mines at Northwich and Winsford, in Cheshire, the Salt Union have mines at Carrickfergus in Ireland, and they have also white salt works at Northwich, Winsford, Middlewich (Cheshire), Stoke Prior and Droitwich (Worcestershire), Middlesbrough (Durham).

11. ROCK SALT IN NEEDLE SHAPED CRYSTALS (One-half scale)

The Uses of Rock Salt. The rock salt is ground to a powder and supplied in bags for agricultural purposes. It is exported in lumps for refining and conversion into table salts. It is placed unground in the stalls of oxen, who greedily lick it as an adjunct to their food. Brine is used in large quantities in the "Solvay" process for the manufacture of alkali; white salt and rock salt in the "Leblanc" process for the production of soda and salt cake [see Acids and Alkalis], also in copper smelting. As such it forms the basis of several of our most important industries, which are dealt with at full length under different sections. Brine also plays a very important part in the process of refrigeration [see Food Preservation]. The following list gives the various uses to which salt is put:

- Scouring
- Removing discolorations
- Washing greasy bottles
- Removing inkstains from carpets and tablecloths
- Removing wine stains
- Carpet cleaning
- Dissolved in spirit for removing grease spots
- Washing silk handkerchiefs
- Mixed with oil for furniture polishes
- Cleaning straw matting
- Cleaning brooms
- Disinfecting
- Cleaning slimy sponges
- Cleaning stained hands
- Cleaning copper (with lemon added)
- Making a fire burn up
- On frozen roads
- Consolidating roads
- Destroying insects in gardens
- Destroying vermin in manure heaps
- Weed killing
- Doctoring horses, cattle, and sheep
- As food for cows to improve milking

12. OPAQUE ROCK SALT (One-half scale)



10. ROCK SALT WITH ATTACHED STONE (One-half scale)

- With food for cattle to improve appetite and digestion
- With poultry food
- With all foods deficient in salt
- As medicine
- In brine baths
- As an antidote to poisons, snake and dog bites
- Improving the burning of paraffin
- Preserving potatoes
- Salting down vegetables before cooking
- Removing animalculæ from raw vegetables, such as watercress
- Salting butter
- Bread making (added to flour)
- Plugging tobacco pipes
- Eating with fruit
- Preserving meat
- Extracting frost from frozen vegetables
- Detecting poisonous mushrooms
- Preserving milk
- Preserving eggs
- Curing hams and bacon
- Fish curing and preserving
- In liquid form, as a fire extinguisher
- Laying dust
- Assisting disintegration and weathering of soil
- Absorbing and retaining moisture on the ground, and therefore as a preventitive of drought
- Assisting the soil to absorb ammonia for crops
- Purifying land
- Placing land to cattle to crop closer
- Increasing clover crops
- Checking or preventing potato disease
- Sweetening and preserving fodder, and preventing mouldiness in it

No distinction has been made between *stove* salt, etc., and *rock* salt in the above enumeration, but it may be taken generally that salt from brine is always used in connection with human food and household purposes, and ground rock salt for all others, except where colour and a high degree of purity is of paramount importance.

Natural Vinegars. Genuine vinegar has been defined as the "product of the alcoholic and acetous fermentation of vegetable juice or infusion." That is to say, it is obtained from some vegetable extract which is allowed to ferment, first with the formation of alcohol, which is then converted into acetic acid. Vinegar so prepared will consist of a solution of acetic acid with various vegetable juices and colouring matters. To this class belong the true malt vinegars, prepared from malt or a mixture of malt and barley. The materials are finely ground and *mashed*—that is, extracted repeatedly with small quantities of hot water till all soluble matters are removed. The clear liquors are run off into a vat, where yeast is added, so that fermentation sets in; carbon dioxide gas is given off, and alcohol formed in the liquor. This alcohol has to be further oxidised to form acetic acid, for which purposes some means is adopted to expose it effectually to the oxygen of the air. The action, however, would be slow were it not for growth of a peculiar fungus, or "vinegar plant" (*Mycoderma aceti*). Either the liquor is allowed to trickle over twigs on which the vinegar plant grows, or the liquor passes through barrels on the sides of which the plant has developed. So prepared, *malt* vinegar has a peculiar and pleasant odour, due to the presence of small quantities of organic substances known as *aldehydes*, *esters*, etc., and it is coloured brown owing to the presence of organic colouring matters formed

13. SCRAPED GINGER

in the process. Small quantities of vinegar are also prepared from inferior wine, but very little prepared in this manner is met with in this country.

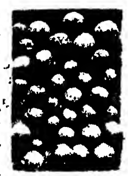
Artifical Vinegars. In contrast to these natural vinegars are the artificial *wood* vinegars, prepared by doctoring a solution of acetic acid obtained by distilling wood and small quantities of caramel, other substances being added to imitate the colour and appearance of *malt* vinegar. A great deal of the vinegar sold is prepared in this way from acetic acid, and at times illegally labelled " malt vinegar." At one time the so-called distilled or *white* vinegar was prepared by distilling the malt vinegar. It is difficult to see what advantages were gained by doing this, as the vinegar so prepared is indistinguishable from diluted acetic acid. A small quantity of sulphuric acid used to be regularly added to the vinegar with the idea that it helped to preserve it. Such an addition is now illegal, and must be looked for in analysing a sample. On evaporating a small quantity of vinegar in a platinum dish to dryness, the solid matter will have a tendency to carbonise even at 100° C. if sulphuric acid be present. Hehner evaporates 50 c.c. to dryness with 25 c.c. of N/10 (NaOH) which is ignited at a low temperature; 25 c.c. of decinormal hydrochloric acid is then added, and the dish warmed to drive off the carbon dioxide. The solution is filtered off from any residue and now contains the free acid originally present in the vinegar, which may be titrated, using phenol phthalein as an indicator in the usual manner.

An opinion can be formed as to whether a sample of vinegar is genuine malt vinegar or not by a combination of tests, such as specific gravity, total solids, nitrogen, phosphoric acid and acetic acid. The latter can be directly estimated by titrating the vinegar with decinormal soda and phenol phthalein as an indicator. Every cubic centimetre of N/10 (NaOH) is equivalent to ·006 grammes of acetic acid.

Pepper. Two varieties of pepper are commonly met with—*black* and *white* pepper. Both are obtained from a climbing plant, the *piper nigrum*, often trained like hops or vines to grow on poles. As soon as the berries show signs of turning red they are picked off and dried. *Black pepper* consists of this dried unripe fruit, in the form of rounded berries about one-fifth of an inch in diameter. The outer covering is then blackish brown and wrinkled and contains a seed of a yellow brown or grey colour. This seed, from which the outer coating has been stripped, forms *white pepper*. For this stripping the fruit is soaked in water in order to soften the husk or outer covering, which is then removed by rubbing. These outer husks possess some of the characteristics of the seed, and are used to a certain extent for flavouring. It will be seen therefore, that the distinction between black and white pepper lies in the fact that the former consists of the seed contained in its husk or outer covering, while the latter is hulled and contains only the kernel. The peculiar pungency characteristic of pepper is due to the presence of an acrid resinous substance, besides which it contains small quantities of an oily body termed *piperin*, starch, and cellulose or woody fibre. The following table represents the average proportions of certain substances in black and white pepper (Clifford Richardson):

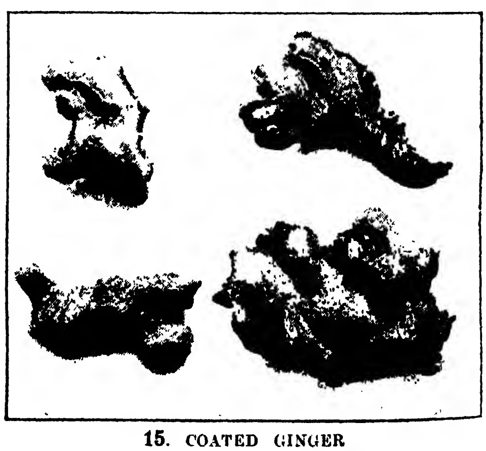
Substances	Black	White
	Per cent.	Per cent.
Water	8 to 11	8 to 11
Ash	2·75 to 5	1 to 2
Volatile oil	·1 to 1·75	·5 to 1·75
Piperin and resin	7 to 8	7 to 8
Starch	32 to 38	40 to 44
Fibre	8 to 11	4·11 to 8
Albuminoids	7 to 12	8 to 10

The manufacture consists in grinding the corns and separating the ground particles by means of sieves. It is found that most of the active constituents are contained in the finely-divided particles, the coarser particles containing mineral impurities and forming an inferior product.



14. PIMENTO

Analysing Pepper. The analysis of pepper is made chiefly for the purpose of detecting adulterants, and much ingenuity has been expended by unscrupulous dealers in incorporating with the pepper substances which are not easily discovered by the analyst. Besides the coarser mineral adulterants, such as china clay and starch, substances such as ground olive stones and *long pepper* may also be added. The difficulty of the analyst is considerably increased by the fact that samples of genuine pepper vary considerably in chemical composition among themselves. The analyst has to rely chiefly on his microscope. Thus, foreign starch will have a different appearance to that peculiar to pepper itself. Any large addition of fibrous material, such as ground olive stones, may be detected by estimating



15. COATED GINGER

the celluloso or crude fibre; thus, unadulterated white pepper may average, say, 6 per cent., black pepper 9½ per cent. Long pepper will contain as much as 21 per cent., and ground olive stones 60 to 70 per cent. Unfortunately, authorities differ a good deal even here, not only on account of the variation in composition of genuine samples, but in the methods employed in estimating fibre.

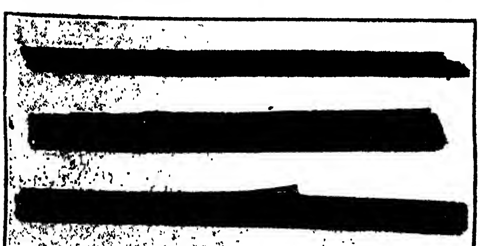
Cayenne Pepper. *Cayenne* pepper is obtained from the dried ripe fruit of the *Capsicum fastigiatum* and *Capsicum annum*, which grow in the tropical parts of Africa and America. The pods are orange-red in colour, perhaps ½ in. or so in length, having a shrivelled appearance. Inside are small white, rounded seeds. It owes its peculiar properties to a body known as capsicum, which is colourless, and has a very acrid taste. In addition to this, cayenne pepper consists of fibres and small quantities of fats and resin, but it is noteworthy that it contains no starch; for analysis the chemist must rely mostly on its microscopical appearance.

Mustard. There are two plants which furnish us with the raw material for the manufacture of mustard—namely, the *black* and *white* mustard plants (*Sinapis nigra* and *alba*), yielding respectively black and white mustard seeds. Both plants are found growing wild in most parts of Europe, the white mustard rather more in the south. The seeds differ a great deal in appearance. The white are about one-twelfth of an inch in diameter, and of a palish yellow colour, while the black seeds are considerably smaller, only about one-fifth of the weight of the white ones, and reddish to dark brown in colour. It is only the black mustard seeds which produce the peculiar volatile oil with the penetrating, pungent odour known as *allyl isothiocyanate*, so irritating to the nose and eyes. It is formed when the seeds are macerated with water. It is, however, a curious fact that the addition of white mustard increases the yield of the volatile oil.

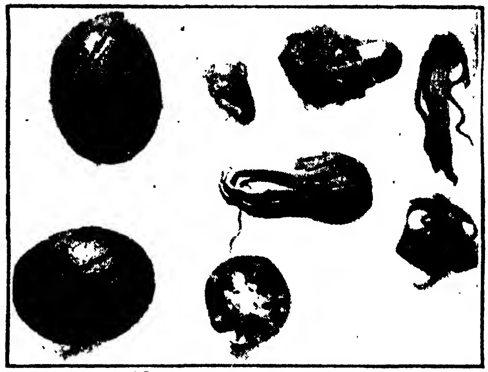
17. CARDAMOMS

To prepare mustard powder, a mixture of the two seeds is crushed between rollers and ground up. The product is then passed through sieves and an impure mustard flour obtained. This flour is then subjected to a second sifting operation, and the product is ready for the market.

The *allyl isothiocyanate* exists in mustard in combination as glucoside (*Potassium myronate*), which is split up in the presence of moisture by a ferment, *myrosin*, also found in the seeds. White mustard contains myrosin, and therefore aids the formation of allyl isothiocyanate, although it does not itself contain any of the glucoside. If you wish to prepare some of this volatile oil you merely require to macerate the black seeds with water, and



18. CINNAMON



16. NUTMEGS AND MACE

after standing for a time, distil, when the oil will pass over with the steam.

In addition to this volatile oil, mustard seeds contain some 35 per cent. of a fixed oil or fat, which is practically odourless and tasteless. There are also present albuminoids, from 25 per cent. to 30 per cent., cellulose, and about 1 per cent. of sulphur. Mustard, however, contains no starch, so that this possible adulterant is easily detected.

The following are the figures obtained in a number of analyses of genuine mustards (Clifford Richardson):

Water	..	3 to 7	per cent.
Ash ..	..	4 ,, 6	,, ,,
Volatile oil	..	·5 ,, 2	,, ,,
Fixed oil	..	31 ,, 37	,, ,,
Starch	..	None	
Fibre ..	..	5 ,, 18	,, ,,
Albuminoids		25 ,, 32	,, ,,

Adulterants of Mustard

In addition to starch, other adulterants which have been detected from time to time are turmeric, cayenne pepper, buckwheat, flour, clay, gypsum, and other mineral matters. Some mustard is poor in oil, being prepared from "mustard cake," the residue left after pressing the oil from the ground seeds. The amount of oil is easily estimated by extracting with ether. [For further details and a description of other processes see ANALYTICAL CHEMISTRY.]

Starch is easily detected by boiling with water, and then testing with iodine. Other adulterants may be detected by estimation of the fibre, albuminoids, ash, and other constituents.

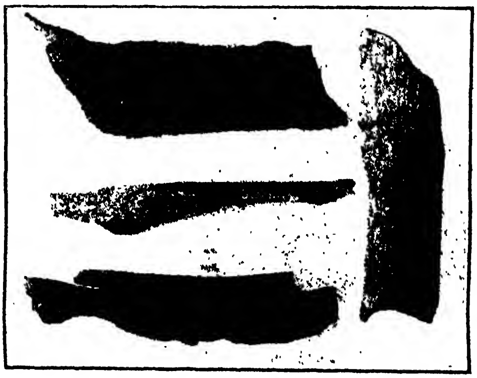
Ginger. Ginger is the dried root, or, more correctly, *rhizome*, of the ginger plant (*Zingiber*), which is a native of India, but has been introduced into a number of other countries, such as Jamaica, Africa, and Japan. The best qualities come from Jamaica. It is prepared by scraping off the outer skin, washing and drying in the sun, and forms rounded, elongated pieces, branching off from one another [13]. The usual colour is a pale buff, but sometimes the outer skin is not removed, "coated ginger" [15], or the scraped root is whitewashed with chalk or chloride of lime to preserve it from the attacks of insects. The peculiar odour of ginger is due to a volatile oil, amounting to about ¼ per cent. of the weight of the root. The pungent taste is due to another constituent. In general, the composition of ginger varies a good deal; it contains resins, starch, fibre, and mineral matters. The following figures will give an idea of the

results obtained in the analysis of several samples (Permain):

	Per cent.
Ash (not including sand)	3·1 to 5·0
Ash soluble in hot water	1·8 „ 2·7
Ether extract (oil and resins)	2·5 „ 5·0
Alcoholic extract after treatment with ether (resins, etc.)	2·7 „ 3·4

Fraudulent practice in dealing with ginger is mostly confined to the sale of the "exhausted" product—that is to say, ginger which has been ground up and the essential constituents removed by digesting with weak spirit for making essences, etc. This form of adulteration is the more difficult to detect as the appearance of the ginger is not altered. A good test for exhausted ginger consists in determining the alcoholic extract after treatment with ether. This should average about 2·8 per cent., while exhausted gingers may average 1·4 per cent. (Dyer.)

Spices. Among the spices, Caraway Seeds are the dried fruit of the *Carum carui*, and contain about 5 per cent. of a volatile oil. Cloves are the dried calyx and flower buds of the *Eugenia caryophyllata*, a sort of myrtle which grows in Zanzibar and the West Indies. As in other spices, they owe their peculiar flavouring properties to a volatile oil, of which they contain up to 16 per cent. Allspice or Pimento [**14**] is the small, dried berry of another variety of myrtle, the *Pimenta officinalis*. It contains about 4 per cent. of an oil similar to oil of cloves. Being cheaper, it is sometimes used to adulterate the latter. Mace is the outer coat or *arillus* of the Nutmeg, the fruit of the nutmeg tree, *Myristica fragrans*. Fig. **16** shows a nutmeg in shell, with the coating of mace, pieces of the mace stripped off, and also the shell broken open with the nutmeg inside. Nutmeg contains 6 per cent. of a pungent volatile oil, and mace about 4½ per cent. of a volatile oil. Cardamoms [**17**] are the dried ripe seeds of several plants, and include the so-called "grains of Paradise." In the illustration two shells have been cut open, showing the black seeds inside. They contain the usual volatile oil and resin. Cinnamon [**18**] is the bark of several allied trees, the best of which comes from Ceylon. The bark is stripped off in spring and autumn. It contains up to 1 per cent. of an essential oil to which it owes its flavouring properties. It is sometimes adulterated with Cassia [**19**], the bark of trees of the same genus, but of inferior value. Cassia is easily distinguished from true cinnamon, the latter consisting of thin curled pieces from which the outer and inner coats of the bark have been removed, while cassia forms thick pieces, consisting of the entire bark.



19. CASSIA

Adulteration of Spices. Spices are very frequently adulterated, sometimes by the substitution of an inferior article, such as pimento for cloves or cassia for cinnamon, and also by the addition of various other waste materials, such as sand, gypsum, walnut and coconut shells ground up, ground olive stones, mustard husks, pepper refuse, etc. These adulterants are readily mixed in with the ground spice, it is therefore much better to buy the whole spice and grind it as required for use. But even then certain adulterations may be effected. Thus cloves may be mixed with an undue proportion of stalks, or the material may be exhausted to remove the essential oil, as in the case of ginger. Under such circumstances, chemical and microscopical analysis alone can supply us with the required information.

Methods of Analysis. In conclusion, we will indicate briefly the methods adopted in analysing the condiments mentioned in this article. Moisture is determined by drying the finely powdered samples at 100° to 105° C. till no further loss in weight takes place. Ash is determined by igniting 2 to 5 grammes in a platinum crucible, and weighing the residue. The ash should be white, or nearly so, and free from black spots due to incompletely burnt particles. Oil and fatty matters are determined by extraction with ether in a Soxhlet. By means of this apparatus ether vapour rising from a flask in which it is made to boil is condensed, and drips on to the substance to be extracted. It is necessary that the solvent used should be volatile like ether. The fibre, or *crude fibre*, as it is sometimes termed, is obtained by taking the residue after extraction with ether, and boiling it (say 2 grammes) with 200 c.c. of 1¼ per cent. sulphuric acid for half an hour, washing free from acid, and then boiling with 200 c.c. of 1¼ per cent. of caustic soda for half an hour, after which the material is washed with water till free from alkali, dried at 100° C., and weighed. The residue is then burnt to ash, and the weight of the ash subtracted from the weight of the dry residue; this gives the weight of the fibre, which, multiplied by 50, gives it in the form of percentage on the original substance taken. For albuminoids, 1 gramme of the substance is heated with 10 c.c. of nitrogen-free, strong sulphuric acid, until the black carbonisation products are completely destroyed and the liquid is white. This operation is hastened by adding 8 grammes of potassium sulphate, which raises the boiling point of the liquid so that it can be heated to a higher temperature. It is best to use special flasks made of Jena glass. When cold, the residue is taken up with water into a large flask, and distilled with soda. The nitrogen of the albuminoids, which has been converted into ammonia by the heating process, now passes over, and is absorbed in a definite quantity of decinormal sulphuric acid. When the distillation is complete, the excess of acid is titrated back. The number of cubic centimetres of decinormal acid neutralised by the ammonia multiplied by ·875 will give the percentage of albuminoids in the original substance.

CONDIMENTS *concluded; followed by* FRUIT PRESERVATION

Continued from page 4621

PARALLELOGRAMS

Sides, Angles and Diagonals of a Parallelogram. Rectangles Simple Propositions referring to Quadrilaterals. Propositions on Parallels. Loci

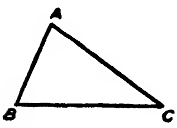
By HERBERT J. ALLPORT, M.A.

Proposition 22. Theorem

If one angle of a triangle is greater than another, then the side opposite to the greater angle is greater than the side opposite to the less.

Let ABC be a $\triangle$ in which $\angle$ABC is $>$ $\angle$ACB.

It is required to prove that AC is $>$ AB.



Proof. If AC is *not* greater than AB, either

AC = AB

or AC is $<$ AB.

Now AC cannot be equal to AB, for then the $\angle$ABC would equal the $\angle$ACB (*Prop.* 5), and the hypothesis states that this is not so.

Neither can AC be $<$AB, for then the $\angle$ABC would be $<$$\angle$ACB (*Prop.* 21), and again the hypothesis states that this is not so.

$\therefore$ since AC can neither be equal to nor less than AB, AC is $>$ AB.

PARALLELOGRAMS

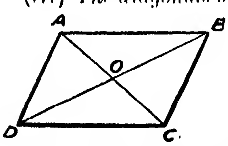
Definitions. A *parallelogram* is a quadrilateral figure whose opposite sides are parallel.

A *diagonal* of a quadrilateral is a straight line joining opposite angular points.

Proposition 23. Theorem

In any parallelogram

(i.) *The opposite sides are equal.*
(ii.) *The opposite angles are equal.*
(iii.) *Each diagonal bisects the parallelogram.*
(iv.) *The diagonals bisect each other.*



Let ABCD be a ▱, and AC, BD be its diagonals, intersecting at O.

It is required to prove that

(i.) AB = CD, and BC = AD.
(ii.) $\angle$ABC = $\angle$ADC, and $\angle$DAB = $\angle$DCB.
(iii.) $\triangle$ABC = $\triangle$ADC in area.
$\triangle$DAB = $\triangle$DCB in area.
(iv.) AO = OC and BO = OD.

Proof. (i.) Since AB is $\parallel$ to CD and AC meets them

$\therefore$ $\angle$BAC = $\angle$DCA (*Prop.* 12);

and, since AD is $\parallel$ to BC and AC meets them

$\therefore$ $\angle$ACB = $\angle$DAC (*Prop.* 12).

Hence, the two $\triangle$s ABC, ADC have two $\angle$s of the one equal to two $\angle$s of the other, and they have also the side AC common to both.

$\therefore$ $\triangle$ABC = $\triangle$ADC in all respects (*Prop.* 19).

$\therefore$ AB = CD, and BC = AD.

(ii.) Since $\triangle$ABC = $\triangle$ADC in all respects

$\therefore$ $\angle$ABC = $\angle$ADC.

Again, it has been proved that

$\angle$BAC = $\angle$DCA and $\angle$DAC = $\angle$BCA.

$\therefore$ the whole $\angle$DAB = the whole $\angle$DCB.

(iii.) We have already proved that the area of $\triangle$ABC = area of $\triangle$ADC.

In the same way it can be shown that $\triangle$s DAB, DCB are equal in area.

(iv.) In the $\triangle$s AOB, DOC

$\angle$BAO = alternate $\angle$DCO (*Prop.* 12)
$\angle$AOB = $\angle$COD (*Prop.* 3)
AB = CD (by i.)

$\therefore$ $\triangle$AOB = $\triangle$DOC in all respects (*Prop.* 19).

$\therefore$ AO = OC, and BO = OD.

Corollary 1. *If one angle of a parallelogram is a right angle, all its angles are right angles.*

In the figure, since AD is $\parallel$ BC and AB meets them

$\therefore$ $\angle$DAB + $\angle$ABC = 2 right $\angle$s (*Prop.* 12).

Hence, if one of these $\angle$s, say $\angle$DAB, is a right $\angle$, the other must also be a right $\angle$. But the opposite $\angle$s of a ▱ are equal.

$\therefore$ all the $\angle$s must be right $\angle$s.

Corollary 2. *If two adjacent sides of a parallelogram are equal, all the sides are equal.*

Definitions. 1. A parallelogram whose angles are right angles is called a *rectangle*.

2. A rectangle whose sides are all equal is called a *square*.

3. A *rhombus* is a parallelogram whose sides are all equal, but whose angles are not right angles.

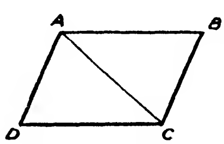
4. A *trapezium* is a four-sided figure having *two* of its sides parallel.

Proposition 24. Theorem

If one pair of opposite sides of a quadrilateral be equal and parallel, the quadrilateral is a parallelogram.

Let ABCD be a quadrilateral in which AB is equal to CD, and also $\parallel$ to CD.

It is required to prove that ABCD is a ▱.



Proof. Join AC.

Then, since AB is $\parallel$ to CD and AC meets them

$\therefore$ $\angle$ BAC = $\angle$ DCA (*Prop.* 12).

Hence, in the $\triangle$s ABC, ADC,

AB = DC,
AC is common to both $\triangle$s,
$\angle$BAC = $\angle$DCA.

$\therefore$ $\triangle$s are equal in all respects (*Prop.* 4).

$\therefore$ $\angle$BCA = $\angle$DAC.

But these are alternate $\angle$s.

$\therefore$ BC is $\parallel$ to AD (*Prop.* 11).

Hence, ABCD is a ▱.

The student should find no difficulty in proving the following propositions for himself.

1. *If the opposite sides of a quadrilateral are equal, the quadrilateral is a parallelogram.*

2. *If the opposite angles of a quadrilateral are equal, the quadrilateral is a parallelogram.*

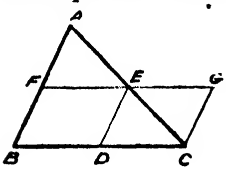
3. *If the diagonals of a parallelogram are equal, the parallelogram is a rectangle.*

4. *If the diagonals of a quadrilateral bisect each other, the quadrilateral is a parallelogram.*

Proposition 25. Theorem

The straight line which joins the middle points of two sides of a triangle is parallel to the third side and equal to half of it.

Let ABC be a Δ, and let E and F be the middle points of AC and AB respectively.



It is required to prove that FE is $\parallel$ to BC, and that FE $= \frac{1}{2}$ BC.

Proof. Through C, draw CG $\parallel$ to BA, to meet FE in the point G.

Then, since FA is $\parallel$ CG, and FG meets them,

$\therefore \angle AFE = \angle CGE$ (*Prop.* 12).

Also, $\angle AEF = \angle CEG$ (*Prop.* 3).

$\therefore$ the Δs AEF, CEG have two $\angle$s of one equal to two $\angle$s of the other, and side AE = side CE.

$\therefore$ they are equal in all respects.

$\therefore$ CG = AF.

But AF = BF.

$\therefore$ CG = BF.

Hence, the figure BCGF has one pair of sides equal and parallel.

$\therefore$ BCGF is a $\square$ (*Prop.* 24).

$\therefore$ FE is $\parallel$ to BC.

Again, to prove that FE $= \frac{1}{2}$ BC.

Bisect BC at D, and join DE.

Then, since DE joins the middle points of two sides of the ΔABC, $\therefore$ DE is $\parallel$ to the third side AB.

$\therefore$ BDEF is a $\square$.

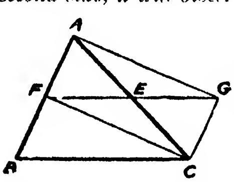
$\therefore$ FE = BD (*Prop.* 23).

But BD $= \frac{1}{2}$ BC

$\therefore$ FE $= \frac{1}{2}$ BC.

Proposition 26. Theorem

If through the middle point of one side of a triangle a straight line be drawn parallel to a second side, it will bisect the third side.



Let ABC be a Δ, and let F be the middle point of AB. Through F draw FE $\parallel$ to BC, meeting AC at E.

It is required to prove that E is the middle point of AC.

Proof. Through C draw CG $\parallel$ to BA, meeting FE at G. Then

BCGF is a $\square$.

$\therefore$ CG = BF (*Prop.* 23).

But BF = FA.

$\therefore$ CG = FA.

Hence, since CG and FA are equal and $\parallel$,

$\therefore$ figure FCGA is a $\square$ (*Prop.* 24).

$\therefore$ the diagonals AC and FG bisect each other (*Prop.* 23), so that E is the middle point of AC.

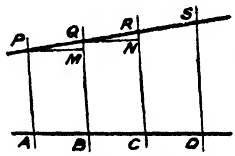
Proposition 27. Theorem

If a number of parallel straight lines cut off equal portions on one straight line, they will also cut off equal portions on any other straight line.

Let AP, BQ, CR, DS be parallel straight lines which cut the line AD so as to make AB, BC, CD equal to one another.

Let PS be any other straight line, cutting the parallels at P, Q, R, S.

It is required to prove that PQ, QR, RS are equal to one another.



Proof. Through P and Q draw PM, QN, $\parallel$ to AD, and meeting BQ, CR at M and N respectively.

Then ABMP and BCNQ are $\square$s.

$\therefore$ PM = AB, and QN = BC (*Prop.* 23).

But AB = BC (*Hyp.*).

$\therefore$ PM = QN.

Again, since PM and QN are $\parallel$, and PR meets them,

$\therefore \angle QPM = \angle RQN$ (*Prop.* 12);

and since QM and RN are $\parallel$, and PR meets them

$\therefore \angle PQM = \angle QRN$ (*Prop.* 12).

$\therefore$ in the Δs PQM, QRN,

$\angle QPM = \angle RQN$

$\angle PQM = \angle QRN$

and PM = QN.

$\therefore$ Δs are equal in all respects (*Prop.* 19).

$\therefore$ PQ = QR.

In a similar way it can be proved that QR = RS.

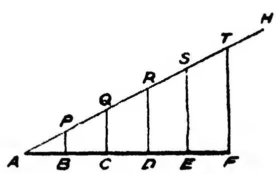
$\therefore$ PQ, QR, RS are all equal.

Proposition 28. Problem

To divide a given straight line into any number of equal parts.

Let AF be the given straight line, which it is required to divide into, say, five equal parts.

Construction. Through A draw a straight line AH, in any direction. Starting from A, mark off five equal lengths, AP, PQ, QR, RS, ST. Join TF. Through P, Q, R, S, draw straight lines $\parallel$ to TF, cutting AF at the points B, C, D, E. (This is done with the aid of set-squares.) Then AF is divided into five equal parts, AB, BC, CD, DE, EF.



Proof. A number of $\parallel$ lines PB, QC, RD, etc., cut off equal portions from the line AH. (*By construction.*)

$\therefore$ they cut off equal portions from the line AF (*Prop.* 27).

$\therefore$ AB = BC = CD = DE = EF.

Loci

The *locus* of a point is the line which it traces when it moves according to some given law. For example, if a point moves so that it is always a constant distance from a given fixed point it traces the circumference of a circle (*Def.* 11). The locus of the point is therefore the circumference of a circle whose centre is the fixed point, and whose radius is the constant distance.

Continued

INSURANCE AS A CAREER

Various Branches of the Profession. Life and Industrial Insurance. How to Become an Actuary. The Institute and Faculty of Actuaries. Examinations

Following on BANKING from page 4590

By W. A. BOWIE

THE business of Insurance consists of the receipt by the insuring office of a sum of money, termed the premium, in consideration of its undertaking to pay a larger sum upon the happening of a certain contingency to the person or property insured. The premium is estimated after consideration of any available statistics relating to the kind of risk which is to be insured against. Let us take an example. From statistics relating to the ages at death of certain observed persons, a table showing the probability of death can be constructed, and upon this table life assurance premiums may be calculated.

The Scope of Insurance. Or, from the record of past experiences of fires in a certain town and in certain classes of property, we can approximately fix premiums which should cover the risk of fire in the same town for the several kinds of property. A moment's thought will show over how wide an area of the world's business the province of insurance extends. Every ship on the sea runs risks hourly which the insurance expert must consider; and every street accident reported by the police is an item in the statistics which govern the fixing of an adequate premium in the great business of insurance against personal accident. It is practically impossible for any one man to be an expert in every department of insurance work, but the profession is one which calls for the exercise in its higher branches of considerable brain power; and many of its developments have proved of fascinating interest to some of the foremost mathematicians of past generations.

We give it as a personal opinion, based upon a wide experience covering many years of work in England and Scotland, that an insurance career is well worth entering upon in the case of a young man with a good education, a fair amount of brains, and an earnest desire not only to do the work assigned to him but to qualify himself by all available means.

Growing Opportunities. While, during the twenty years ending with 1905 the number of first-class insurance offices in the United Kingdom has decreased by amalgamation rather than increased by new ventures, the number of important branches created in the metropolis and the provincial towns has been so great that fresh chances for young men of ability and proper training have been very much extended. A young man who enters a large insurance office is often at a loss to know how to direct his studies, and our aim is to encourage him not only to master the department in which he is placed, but so to cultivate his education in the general subject of insurance that, as he rises to more responsible work, his outlook will be wider and clearer. An example will suffice to show what we mean.

A boy is a clerk in the head office of a large company and is attached for a year or two to the department responsible for the writing out and issue of fire policies. This is only one of a dozen departments of a fire company, but the boy will find that practically all the books and methods of working may, if he likes, come under his observation. He will find, almost invariably, that by exercising a little courtesy towards his superiors he can obtain an answer to any question he may ask concerning their own departments. By reading lectures and papers bearing on these other departments he will form a fair idea of the general lines of work which, on the day when he is promoted to one of the smaller branches of the company, with three or four departments in his charge, will be of considerable use to him. Here let us advise the student to read as many as he can of the papers delivered by experts before the insurance institutes of the United Kingdom, the best of which are published as annual volumes entitled "Journal of the Federation of Insurance Institutes of Great Britain and Ireland." There are, besides, many papers not included in these collections which would well repay perusal. Most of these publications are to be found in the libraries of the various insurance institutes, and in the head offices of the larger companies.

A knowledge of shorthand often brings a young clerk into close contact with one of the chiefs in the office, and, if he has the ability to rise, the youth will often be picked out for some occasional special service. A good knowledge of arithmetic is indispensable.

The chief branches of the business of insurance are *life*, *fire*, *marine*, *accident* and *contingency*.

Life Assurance. We will take first the life branch, which has been most highly developed on scientific lines. The theory of life contingencies may almost be said to be an exact science, and its study as applied to insurance constitutes an entire branch of the profession. A young man who enters a life office may, if he is quick at figures and fond of mathematics, think it worth while to study in order to pass all the examinations necessary to become an actuary. We shall come later to discuss the lines on which he should proceed in order to reach this coveted position. Many young men, however, who promise to develop good business capacity may be altogether unsuited for the higher branches of mathematical work. For them a position as secretary or manager may be the goal.

Life Office Work. Let us look first at the *non-actuarial departments* of a life office. A youth must quickly make himself acquainted with the methods of securing proposals and dealing with the policies issued. The proposal forms have to be scanned to see that no irregular answers are given; and the variety of policies issued, with the precise phraseology used in each case, should be noted. Any special conditions endorsed on the back of policies are of great importance, often modifying the contract, or charging extra premiums for special risks. Insured "lives"—the insurer is known in the insurance office as a "Life"—sometimes transfer their policies in security to a bank or a private individual. The transaction is called an *assignment*, and notice of it is generally given to the company.

Questions of title often arise as to whom the policy really belongs, and the correspondence with the persons interested in the matter is generally well worth study. It may be pointed out here that it is highly essential that a clerk should early learn to compose a good letter. The writing of a few essays in a literary society is a capital aid to the cultivation of a good style. Every young man should make a point of reading both the letters received and the copies of the answers which will have been filed. The correspondence, which is generally free to the clerks, is an education in itself and will show an expert manager's methods of dealing with difficult matters as they arise.

The methods of attending to the collection of renewal premiums should be closely observed, particularly the precautions taken to see that one premium is paid before notice for another is despatched. The student will also become thoroughly acquainted, not only with his own company's prospectus and table of rates, but with those of other companies as well, noting special conditions as to bonus distribution, foreign residence, surrender values, and the like.

Office Books and Accounts. It is very important that a careful record of all transactions in connection with each policy be entered on the registers, and the sooner a clerk becomes familiar with the use of each book in the office the better for his prospects. He must know the principles of bookkeeping [see CLERKSHIP] and how they are applied to the accounts of the departments of his own office. He should notice how premiums on new and renewal policies are debited to agents and collected by them; how agents' commissions are allowed and paid, and how all financial transactions are brought by skilful summary, at the end of six months or a year, to a focus in a single statement called a *Revenue Account*.

Claims. Life offices are concerned not only with receiving money, but with the payment of sums on the death of the insurer, or, perhaps, on his reaching a certain age. The aim of the office should be to meet a claim as promptly as possible, and for this purpose to grant every facility to the persons interested. Many a good fresh insurance has been secured by the ready settlement of a claim. A study of the causes of death, and of the original medical report when the insurance began, will often reveal how some weakness undetected at the start has been the cause of ultimate death; or the family history may show that there is a tendency to premature death from certain causes which have affected the insured as well as his family. It is always helpful to notice with what skill the chief medical officer and the actuary or manager have dealt with hazardous lives, and how far their action has been justified.

Loans and Investments. The lending of money does not generally come much before the office staff. The directors and the manager deal with questions of immense importance when, at the board table, they decide how many thousands of pounds are to be safely invested. But the study of the investment ledger and of the annual balance-sheet will show a learner on what careful lines a British board of directors puts money by. Care is always observed that no speculative securities are bought, even if they yield a high rate of interest. The securities purchased must, however, yield a good and safe return. Fortunately a life office can lend money for long periods, and therefore it is often approached by those who do not wish their mortgages to be disturbed so long as the interest is duly met. A war, or great stagnation of trade, may often depreciate the value of first-class securities, and an insurance company must be careful not to put too high an estimate upon stocks in its balance-sheet. In 1903, for instance, Consols and other first-class investments had depreciated to such an extent that many insurance offices were compelled to write off as a loss sums running into thousands of pounds, because their securities had fallen below the current selling value. Some companies undertake the granting of loans combined with life assurance on security of comparatively small houses, and a wide field is opened out for the study of surveyors' reports to find what are the different precautions taken on behalf of the lending company to ensure that the property is safe and can readily be sold if default takes place.

The Legal Department. Questions of law constantly arise in many connections. A policyholder has assigned his policy and wishes to know how he can get it re-transferred to himself. Or he has taken out his policy in favour of his wife and she has died. What is he to do? A member dies and it is found that he has pledged the interest in his policy in security to one man, with a second charge upon it to another. How are their claims to be adjusted? A man dies without leaving a will How is the company to know to whom to pay the sum due under his policy? A junior clerk of an inquiring turn of mind will find pleasure in searching for the correct answers to these questions in handbooks on the law of life insurance, or in perusing a well-formed judgment expressed in a letter from the solicitors of his company bearing on a special case.

There are a number of special Acts of Parliament to be studied in connection with life assurance. The following are the most important.

The Gambling Act, 1774.

The Policies of Assurance Act, 1867.

Life Assurance Companies Acts, 1870 to 1872.

Married Women's Property Act, 1870 (Sec. 10).

Married Women's Policies of Assurance (Scotland) Act, 1880.

Married Women's Property Act, 1882 (Sec. 11).

In the latest edition of Bunyon's book on the law of life assurance the chief points are dealt with, and the student should study this book, especially with regard to any particular case which may arise in the office.

Agency Department. A life office never grows very quickly and is often in danger of dwindling to small proportions unless it has an active agency department for securing a fresh access of new life proposals; and the young man who wishes to succeed in other than actuarial departments will find quick promotion if he is able to introduce new assurers, either by his own personal influence or by his skill in stimulating agents.

Life proposals are generally secured by personal canvassing. An outdoor man must have confidence in himself and in his company, good address, and plenty of perseverance. He must be ready in securing introductions, and ingenious in bringing a tardy client to the insuring point. If a clerk shows canvassing ability, he will receive every encouragement to act as an *Inspector of Agents*, and will be on the high road to a post as branch secretary when he can point to a good record of business. Our rising man in the outdoor department will concern himself with methods of advertising the company, and of encouraging the public, by circularising and otherwise, to apply for a prospectus. He must learn how to secure business without paying extravagant commissions, and how to encourage agents to keep constantly on the look-out for fresh insurers.

The Chief Schemes for Life Insurance. It is sometimes bewildering to the outsider to find in how many different ways life insurance can be applied. New schemes are constantly being issued by the companies, but these are often meant for ingenious advertising rather than planned for any great practical good. The student will find that the great bulk of life insurance is done under one or other of the following heads.

1. Whole Life Assurance.

2. Whole Life Assurance with Premiums limited to ten, fifteen, or twenty payments.

3. Endowment Assurance. Sum assured payable at death or at an agreed age like fifty or sixty.

4. Joint Life. Sum assured payable at the death of the first of two lives; perhaps a husband and wife, or two partners in business.

5. Short Term Insurance, covering perhaps one year only, or five, ten, or twenty years, protection ceasing at the expiration of the term.

6. Children's Assurances. Sum assured payable only on the life reaching age of twenty-one, or risk beginning at age twenty-one, and sum assured payable at death or at an age like fifty or sixty, or previous death.

7. Annuities. A sum of money is paid down to secure an annual allowance until the death of one or more lives.

Bonuses. Policies may be taken out with or without profits (or bonuses). In the latter case a man receives the largest possible cover for the smallest possible premium. In the case of policies sharing in profits the offices are most liberal in granting at each period of distribution a very large share—generally nine-tenths—of all profits earned by the company, including any profits made on non-bonus policies, so that in a well-managed society a life policy may not only be a very fine form of protecting the family, but may also prove a capital investment, giving a rate of compound interest higher than could be had from Government securities. First-class life offices pay very substantial bonuses, but a comparison between the profits declared by first-rate companies and those granted by offices not so well managed and financed will form an interesting study.

Survival Bonuses. Of special interest is the method of only granting bonuses should the assured survive for, say, twenty years. This method appeals to some, because it contains a speculative element, and, of course, the bonuses in such a case ought to be about double those granted by the companies who divide profits every five years or thereabouts. As a matter of experience, however, it is found that the ordinary British offices' bonuses at the end of twenty years often amount to more than the tontines bonuses declared at the end of that period in some inferior office, while valuable additions to the sum insured by way of profits have been made by the first-class offices during the intervening years.

Re-assurances. Offices have a limit to the amount which they will insure on any one life. It happens constantly that wealthy men apply for large insurances in one office. It will be the duty of an official to arrange for re-assuring the surplus portion of the risk with one or more other offices. To do this copies of the proposal, medical, and all other reports and papers bearing on the case are submitted to the office approached. The rate offered to the re-assuring company may be that of either office.

If the risk be accepted, a copy of the policy is generally supplied to the company sharing the risk, and on this copy a guarantee is endorsed, agreeing to accept so much of the insurance within described. Sometimes the guarantee is by direct policy, the company which accepts part risk agreeing to follow the terms and conditions of the original assurance.

A separate register is kept in which to enter all re-insurances and also a book showing on one side how much in sums assured and premiums has been given off to each office, and how much in sums assured and premiums has been received in return. It is desirable to see that other offices do not get too great a share of surplus lives without giving adequate business in return.

Industrial Insurance. The rise and progress of industrial insurance might be fitly studied by reading the history and development of the Prudential Assurance Company. The Prudential is the oldest and largest industrial company, and it has justified its existence in many admirable ways. By close attention to the needs of the poor, by skilfully constructed tables, by careful selection of outdoor inspectors and constant supervision through local and district superintendents, the Prudential has attained its present position.

The distinguishing features of industrial assurance are these: premiums are met by weekly payments, generally called for by the company's canvassers at the houses of the working classes, the sums assured being determined upon the basis of how much can be secured for a penny a week and upwards. The expense of working industrial insurance is about 40 per cent. This certainly appears very high, but it is fully justified by the enormous trouble to which the collectors are put.

In this class of insurance there is generally no medical examination, the agent being relied upon to use his judgment and discretion before accepting a risk. There are now many attractive positions occupied in the industrial insurance world by men who began as door to door canvassers, and through energy and success have been promoted, first to the position of assistant superintendant, and then to the desirable post of superintendent or district manager.

Importance of Actuarial Knowledge. It is, of course, impossible, even undesirable, that the whole staff of a life office should become actuaries; but the fact that his duties are non-actuarial is no excuse for ignorance on the part of any official regarding the elementary principles on which life assurance is based. To the branch secretary, agency inspector, and to outdoor men generally, a knowledge of the principles of life assurance is of the greatest assistance, enabling them to answer inquiries from probable assurers, to understand the schemes of rival companies, and in many cases preventing waste of time on undesirable cases. Such officials should make a point of solving each difficulty as it presents itself, and they will then find in a comparatively short time that their knowledge is really considerable. They should seek for information principally in the "Transactions of the Federation of Insurance Institutes," the papers therein being both useful and interesting. Other books which will also be found very useful are "Life Assurance Explained" (Schooling); "Practical Information for Life Assurance Agents" (Wm. Hughes); and "Insurance" (T. E. Young).

Actuarial Symbols. At the outset the actuarial symbols met with appear to be very imposing, and are calculated to dishearten those to whom they are unfamiliar. In reality they represent merely a system akin, let us say, to Pitman's shorthand. For example, the symbol ax may be said to be the "actuarial shorthand" for the value of an annuity of 1 per annum, payable at the end of each year during the life of a person aged x. Similarly Ax is "the value of, or the single premium for, an assurance of 1 payable at the end of the year of death of a life now aged x; and Px is the annual premium, payable at the beginning of each year during the life of x, which will provide a similar assurance of 1. The notation employed is entirely arbitrary, and the only way to understand it is to commit it to memory. The system will be found in the beginning of the "Institute of Actuaries Text-book," Part II; and as it is most graphic, the task of learning it is really an easy one.

Many of the simpler relationships employed in actuarial work can be established verbally, without reference to the algebraic qualities of the symbols employed. For example:

$$Ax = (P + Pax) \text{ or } P\,(1 + Ax).$$

It is evident in view of the above definitions that Ax, the single premium for an assurance of 1, ought to be the equivalent of the annual premium multiplied by Ax (the value of an annuity of 1 per annum payable at the end of each year) plus, in addition, Px, the first annual premium. Of course, either Px or Ax has, in practice, to be increased, or "loaded," by an amount sufficient to cover expenses and profit.

Again, a policy value or a policy reserve can be easily explained. At the issue of a policy the present value of the benefit is equivalent to the present value of the future premiums (leaving the "loading" out of account), but afterwards the value of the benefit exceeds the value of the future contributions, and the difference is the policy value.

This can be well expressed in the form of an account:

Present value of sum assured after n years, $x + n$ being then the attained age	$= Ax + n$	Present value of future premiums	$= Px(1 + Ax + n)$
		Balance is policy value represented by	$n\,Vx$
	$Ax + n$		$Ax + n$

and therefore $n\ Vx = Ax + n - Px(1 + Ax + n)$; or, as stated above, the policy value equals the value of the benefits less the value of the future contributions.

Other points on which information is useful are the various defects in family and personal history on account of which extra premiums are imposed; the merits or demerits of various bases of valuation, and the rationale of surrender values. Information on these and other points will be found in the literature referred to in such a form that little difficulty will be experienced in assimilating it.

All actuarial tables are given in decimals, and it is well to learn how to turn these readily into shillings and pence, and vice versâ.

It must be borne in mind that, however clearly the symbols employed may be understood, no one is competent to judge when a table is suitable for use unless he thoroughly understands the methods and data employed in its construction.

and this point cannot be too strongly emphasised.

Typical Examination Questions. The following questions on life assurance and life office work set at one of the examinations will give some idea of the knowledge which a life official, though not an actuary, ought to possess:

(*a*) A policy-holder, under a whole life policy by annual payments payable during life, desires to commute the future premiums to ten further payments, and has paid the first increased premium of £10. The premiums are due on April 1st. Draft a form of endorsement to be placed on the policy.

(*b*) State what you know as to the different systems of insuring lives without medical examinations.

(*c*) An annuitant desires to surrender his annuity. Should this be agreed to, and if so, under what conditions ?

(*d*) A policy is payable to an assured's executors, administrators, or assignees, and has not been dealt with in any way. What is the title in England, Scotland, and Ireland (1) when the assured has left a will; (2) when no will has been left ?

(*e*) When does the liability of an insurance company under a life policy commence ?

(*f*) What special allowance for income tax does an insurer receive from the Government ?

(*g*) What are the stamp duties on (1) a policy of life insurance ; (2) an annuity bond ; (3) a mortgage ; (4) an absolute assignment ; (5) a memorandum of deposit ; (6) an assignment to marriage contract trustees ?

(*h*) A policy has become a claim. It has been assigned. What is the procedure as regards delivery and custody of the deed of assignment in England :

(1) When the deed also conveys a policy on the deceased's life with another office ?

(2) When there are other effects conveyed ?

(*i*) Should a loan be granted to a policy-holder on security of his policy if he has lost it ? Should a surrender value be granted ? What is the procedure in such a case when the policy becomes a claim ?

(*j*) A policy-holder who has been insured for some years wishes to surrender. He points out that since his insurance has involved no loss to the office he considers he should get a return of at least all the premiums paid, since the office has had the benefit of the interest on the premiums. Draft a reply.

(*k*) An agent has been so frequently in arrear in the rendering and payment of his accounts that the office has decided to collect the premiums in his agency direct, crediting him with the commission. Draft a letter telling him of the office's decision, and one to the policy-holders in his agency informing them of the new arrangement.

(*l*) Explain fully any three bonus systems, and the advantages and disadvantages of each.

(*m*) A policy for £500 is effected in April, 1905, in an office which divides its surplus quinquennially, the next investigation taking place in December, 1908. On the basis of a compound bonus of 30s. per cent, per annum for each premium paid, with an intermediate addition of 25s. per cent., state what the amount payable would be in the event of death in November, 1915.

How to Become an Actuary. An actuary is one who has to solve for insurance companies, friendly societies, and similar institutions, financial questions that involve a consideration of the separate and combined effects of interest and probability in connection with the duration of human life, sickness, marriage and other contingent events ; or, more generally, an expert in the application of the doctrine of chance to monetary affairs, more particularly in respect of the insurance of life. Hence his chief duties are to make the computations necessary to determine the value of contingent liabilities, the compilation of mortality and other statistical tables, and the calculation of premiums.

On such calculations depends the practice of life assurance, and it is therefore evident that a skilled actuary is of final importance to the successful conduct of an office engaged in life insurance and annuity business. The governing authorities are, in England, the Institute of Actuaries, founded in 1848, and incorporated by Royal charter in 1884, and, in Scotland, the Faculty of Actuaries, formed at Edinburgh in 1856 and incorporated by Royal charter in 1868.

There are two principal ways for the "junior" in a life assurance office to gain promotion ; he may either become an actuary or a good "field" worker and organiser. No man, however, is put to outdoor work until he has had a number of years' experience in office routine ; and these years may with advantage be devoted to the attainment of actuarial training and experience. Both the outdoor man and the actuary are necessary to the life assurance office, and the man who is doubly qualified stands a better chance of reaching the highest position.

Preliminary Steps. The first step which the future actuary must take is to get himself enrolled either as a probationer of the Institute, or as a student of the Faculty. These are kindred institutions, and a resident in England, Ireland, or the Colonies would probably join the Institute, and a resident in Scotland the Faculty. Those who wish to join the Institute should write to the Assistant Secretary, Staple Inn Hall, Holborn, W.C., asking for a form of application for admission to the class of probationer and for a syllabus of the examinations. This form must be filled up and signed by two members of the Institute, either Fellows or Associates. Probably there will be in the applicant's own office at least one official of either status, but, should this not be the case, he should get his principal to assist him in obtaining the necessary introductions. Those who wish to join the Faculty should write to the Secretary, 24, George Street, Edinburgh, for an application form and syllabus. In this case the application has to be recommended by two Fellows of the Faculty.

The Institute requires the candidate to pass four examinations, known as Parts I., II., III., and IV., held in April of each year, before admitting

him to the class of Fellow (F.I.A.), although passing Parts I. and II. only will admit him to the class of Associate (A.I.A.). The Institute examinations are held at these centres: London, Edinburgh, Dublin, Adelaide, Melbourne, Sydney, Wellington, Montreal, Toronto, and Ottawa.

The Faculty requires the candidate to pass three examinations, also held annually in April, but only in Edinburgh for the first, and only in Edinburgh and London for the second and final examinations, before admitting him to the class of Associate, and thereafter admits him to the class of Fellow (F.F.A.) without further examination.

Graduates in mathematical honours of any university in the United Kingdom are exempt from the first examination in the case of both the Institute and the Faculty. Also in both cases admission to the class either of Associate or Fellow cannot be obtained before the age of twenty-one years, although the examinations may be passed earlier.

The Institute examinations involve the study of a larger number of subjects than do those of the Faculty, and in this course attention will mainly be devoted to the former, the differences between the two syllabuses, however, being indicated.

It may be well to state at this point that a resident in England, especially if connected with an English company, would be ill-advised to join the Faculty. The absence from the Faculty syllabus of certain items appearing in that of the Institute detracts materially from the value in England of the Scottish qualification. Obviously, too, a student residing in England can derive little benefit from a library in Edinburgh, and has no opportunity of meeting with other members of the institution; and, further, if he resides in London, he will lose the great advantage of being able to attend the classes provided by the institute.

The Institute of Actuaries Examinations. Assuming, then, that the candidate is enrolled as a probationer of the Institute, we give a concise description of the subjects which he will have to study, of the classes he should attend, and of the principal books he should read. [See also Schedule herewith.]

Examination Part I.

The Institute provides a tutor for Part I. of the examinations, and the probationer living in London should certainly join his class. Probably, for most students, this will be sufficient coaching for the first examination; but the class is generally a large one, and a student who feels that he requires special attention will do well to go to some other tutor in addition.

The Institute issues this initial regulation: "For admission to the class in Part I. the candidate must possess a fair knowledge of algebra up to and including quadratic equations."

This indicates the minimum amount of mathematics which the probationer must know, and enables any student to decide for himself whether he requires a preliminary course of study. The official class not being available to probationers resident in the provinces or abroad (unless they choose to come to London for the purpose), they must procure the services of a tutor; but, since there is nothing technical about the examination in Part I., any competent mathematician will suffice. If the tutor chosen has had no experience in preparing students for this examination, he should obtain copies of previous papers in order to ascertain the probable character and standard of the questions. The beginner, however, will, in many cases, be able to study under a qualified actuary, who will be conversant with these points.

Every candidate will receive advice as to the opening of the class, which is held in the evening, and he has then merely to attend the first meeting and pay his fees to the Assistant-Secretary. [See Schedule.]

The books which should be read in preparation for the first examination are Hall and Knight's "Higher Algebra" (Macmillan, 7s. 6d.); the introduction to some standard book of logarithmic tables; "Elements of Finite Differences," by Burn and Brown (C. & E. Layton, 7s. 6d.); and the chapters in Part II. of the "Institute Text Book" dealing with the fourth division of the syllabus. The theory of probabilities is dealt with in Hall and Knight's "Higher Algebra," but the student should also read some other work on the subject. Messrs. Ackland and Hardy's "Exercises and Examples" (C. & E. Layton, 10s. 6d.) will be found of great use in preparing both for this examination and the examination in Part II. A knowledge of the game of whist is very desirable. A game of cards not infrequently forms a setting for a problem on probabilities, and whist is invariably the game selected. The following question, set in 1905, illustrates this point and is a good example of a problem on probabilities. "In a game of whist, the dealer found, on turning up the last card, that he had the ace, king, queen, knave, ten and three other trumps in his hand; find the chance that this would occur." Here the essential point is that the dealer, having turned up the last card, must have at least one trump, which, of course, materially affects the probability or chance required.

Examination Part II.

Coming now to Part II. of the examinations, the Institute has published this reminder: "Candidates for the class in Part II. should have read the 'Institute of Actuaries' Text Book, Part I.'"

This book deals with subjects not comprised in the syllabus for Part I., and it is therefore necessary to study it in the interval between passing the first examination in April and joining the Part II. class, which is held during the winter months. Most men will find that they require no special assistance for this, but some may feel the need for a tutor, who, since the subject is technical, should certainly be an actuary. No doubt the tutor for the class in Part II. would not ignore Part I. of the "Institute Text Book," but he is entitled to assume that the members of his class have some knowledge of its contents.

SCHEDULE OF EXAMINATIONS FOR ACTUARIES

Examining Body, Grades, Time and Place of Examinations	Subjects of Examinations	Fees
INSTITUTE OF ACTUARIES. Students. Associate.	**Part I.**—Arithmetic and Algebra. The Theory and use of Logarithms. The Elements of the Theory of Probabilities. The Elements of the Calculus of Finite Differences, including Interpolation and Summation.	£1 1 0
	Part II.—Compound Interest and Annuities-certain. The Application of the Theory of Probabilities to Life Contingencies. The Theory of Annuities and Assurances on Lives and Survivorships. The elementary application of the Calculus of Finite Differences, and of the Differential and Integral Calculus, to Life Contingencies. Expressions for the Law of Mortality. The principles (as distinguished from the methods) of the construction of Mortality Tables (excluding graduation); and the principles and methods of the construction of monetary and other Tables involving the Contingencies of Life.	£1 1 0
Fellow.	**Part III.**—The methods of constructing and graduating Mortality, Sickness and other Tables. The history and distinctive features of existing Tables. The valuation of the Liabilities and Assets of Life Assurance Companies. The Distribution of Surplus. The Calculation of Office Rates of Premium for Assurance, Annuity, Sickness and other risks, excluding Pension Funds and Widows' and Orphans' Funds. The practical valuation of Life Interests and Reversions, and of Policies for surrender or purchase	£1 1 0
April. London, etc. (see text).	**Part IV.**—The Elements of the Law of Real and Personal Property. The Law relating to Life Assurance Companies and Life Assurance Contracts. The Constitution, Valuation, and Calculation of Rates of Contribution of Friendly Societies, Pension Funds, and Widows' and Orphans' Funds; and the Laws relating to such Institutions. Life Assurance Bookkeeping; preparation of Schedules, Statements and Reports. The Principles of Banking and Finance, including a knowledge of the Constitution and Operations of the Bank of England, and of the National and Local Debts of the United Kingdom. The Investments of Life Assurance Companies.	£1 1 0
Graduates in Mathematical Honours of any University in the British Empire may, at the discretion of the Council, be exempted from Examination in Part I. of the Syllabus.		
FACULTY OF ACTUARIES. Student. Associates and Fellows.	**First Examination.**—Arithmetic. Equations. Series. Permutations and Combinations. Binomial Theorem. Theory and use of Logarithms. Elements of the Calculus of Finite Differences. Theory of Probabilities.	No fee on first sending in name for examination, but £1 1s. on each subsequent occasion.
	Second Examination.—Interest and Annuities-certain, with Construction of Monetary Tables. Probabilities of Life and of Survivorship. Theory of Life Contingencies, including Annuities and Assurances, with construction of relative Tables. History and Characteristics of Mortality Tables. Application of the Calculus of Finite Differences to Life Contingencies. Elements of Differential and Integral Calculus.	
April. London and Edinburgh (see text).	**Third Examination.**—Mortality, Marriage and Sickness Investigations, including Construction of Tables from actual or from hypothetical data. Graduation of Tables. Formulas for Summation and Interpolation. Application of the Differential and Integral Calculus to Life Contingencies. Life Assurance Finance and Practice, namely: Calculation of Premiums. Valuation of Assets and Liabilities. Distribution of Surplus. Surrender and Conversion of Policies and Bonuses. Book-keeping and Accounts. Investments. Miscellaneous Questions. Law of Life Assurance. Reversions, Life Interests and other Contingencies. Widows' Funds, Superannuation Funds, and Friendly Societies—Calculation of Rates, and Valuations.	

QUALIFICATIONS WHICH SECURE EXEMPTION FROM THE ABOVE EXAMINATIONS

Any student who has taken a degree at one of the Universities of Great Britain or Ireland, Mathematics being one of the special subjects of examination for such degree, being 21 years of age, may, in the discretion of the Council, be exempt from the first of the examinations mentioned above.

The syllabus for the examination in Part II. may be roughly summed up by saying that it consists of the Algebra of Actuarial Science and of the Principles of the Construction of Tables of Mortality and other tables. [See Schedule]

The principal books to be read are the "Institute Text Book," Parts I. and II. (obtainable at the Institute, 10s. 6d. and 31s. 6d. respectively). King's "Theory of Finance" (C. & E. Layton. 4s.) may also be read with advantage, although, since the same ground is covered by Part I. of the "Text Book," it is not essential. It will also be necessary to read some book on the Differential and Integral Calculus, and whatever textbook is chosen the student will find a knowledge of Trigonometry useful. [See MATHEMATICS.]

The Principles of the Construction of Mortality Tables is the only remaining subject in the syllabus for this examination. The "Institute Text Book" deals with the subject, and many papers besides have appeared in the "Journal of the Institute of Actuaries." Although the construction of Mortality Tables is explicitly excluded from the syllabus of Part II. and appears under Part III., yet it is difficult to study the Principles of Construction apart from the actual construction. The student is recommended to study the construction of certain representative tables, but to bear in mind whilst so doing that he will be examined only on the principles underlying that construction.

The student should read the following papers in the "Journal of the Institute of Actuaries": Volume IX., on the "Healthy English" Table, and on the "Peerage" Table; Volume XVIII. on the "Carlisle" Table; three papers in Volume XXXI., by Sprague, Meikle, and Whittall, dealing with various methods and tables: and in Volume XXXIII. the paper by Ackland. He should also read the Introduction to Farr's "English Life Table No. 3"; Finlaison's "Report on Government Annuitants, 1883," and

Sprague's criticism thereon; the introduction to the "Institute Mortality Experience," and, most important of all, the "Account of Principles and Methods" adopted in the construction of the British offices' life tables. The student for Part II. should ignore all portions of these books which are concerned with graduation.

Examination Part III.

The Institute does not at present provide a tutor for either Part III. or Part IV. In recent years, however, a course of lectures by an expert has generally been held upon some subject which comes within the scope of the syllabus. These lectures have been printed and are of great assistance. Lectures are also delivered at the London School of Economics on various insurance subjects, and those courses which meet his requirements should be attended by the student. Notwithstanding this aid the student is more dependent upon private coaching than when preparing for Parts I. and II., and the best advice which can be given him is to join the class of a well-known tutor and, so far as possible, make no change until both Parts III. and IV. have been passed.

A certain amount of work towards the subject under the first heading in the syllabus for Part III. has necessarily been done in preparing for the second examination. Sickness tables, however, have not yet been studied, and this is the student's first introduction to the subject of Graduation.

Graduation. When a mortality table is constructed it is found that there are certain irregularities, arising from various causes, which would interfere with the practical value of the table. These irregularities require adjustment, and it is to this adjustment of the original observations that the term "graduation" is applied.

In preparation for the examination in Part III. there are numerous papers and letters in the "Journal of the Institute of Actuaries" which should be read, and also papers in the "Transactions of the Actuarial Society of Edinburgh," in the "Journal of the Statistical Society," and in the "Transactions of the Faculty of Actuaries."

The student should also read (in addition to the books mentioned in connection with the Principles of the Construction of Mortality Tables under Part II.), the introduction to Sutton's "Sickness Tables"; Watson's "Manchester Unity Sickness Tables"; the Annual Reports of the Registrar-General, especially those issued on completion of the decennial censuses; Bowley's Lectures on the "Measurement of Groups," G. F. Hardy's Lectures on "Graduation"; and the "Report on the Mortality of London" issued by the London County Council.

Valuations and Distribution of Surplus. In connection with items 3 and 4 of the syllabus, every student should make himself familiar with the methods of valuation and distribution of the disclosed surplus in use amongst life offices at the present time. This can best be done by studying the blue-books issued by the Board of Trade each year, which contain the Returns made by the Companies under the Life Assurance Companies Act, 1870. It should be particularly noticed how each method of distribution affects the incidence of the bonuses declared.

In order to acquire practice and facility in the valuation of reversions and life interests the student, unless he makes such calculations frequently in the course of his office work, should value such interests as he sees advertised for sale by auction and compare his results with the prices obtained.

Examination Part IV.

This examination may be taken the same year as Part III., but, having regard to the amount of reading which has to be done in preparation for Part III. only a really brilliant man has much chance of passing both parts together. On the other hand, Part III. being disposed of, a single winter's work should bring almost certain success in Part IV., and to take each part separately appears in most cases to be preferable.

The syllabus of the Examination in Part IV. consists largely of subjects which are not purely actuarial, but a knowledge of which is very necessary to the actuary. [See Schedule.]

Books to Read. The following books should be read: Strahan's "Law of Property" (Stevens & Sons. 12s. 6d.), or, if the student has time to read a full exposition on the subject, "Williams on Real and Personal Property"; Lectures by Wood Hill on "The Law of Real Property," by Hayter on "The Law of Mortgage" and by Clauson on "The Companies Acts" (obtainable at the Institute, 1s. each); and Indermaur and Thwaites' "Guide to Real and Personal Property" (Stevens & Haynes. 10s.). The last mentioned book will be found invaluable for revising the student's knowledge of the subject. Bunyon's "Law of Life Assurance" should be read, and certain Acts of Parliament, such as the Life Assurance Companies Acts, 1870-2; the Friendly and Collecting Societies Acts, 1896; Companies Act, 1900; and the Finance Act, 1894, must receive special attention.

A small book, entitled "How to Read the Money Article," by C. Duguid (Effingham & Wilson), is an admirable introduction to the financial part of the work. Clare's "Money Market Primer," "A.B.C. of the Exchanges," and also his "Lectures on the London Daily Stock and Share List," and some works on bimetallism and mono-metallism, should be studied. The student should read regularly the financial articles in one of the leading morning papers, and should also make a point of seeing regularly one of the financial weeklies, "The Economist" for preference.

No textbook can adequately deal with the subject of investments, knowledge of which can only come with experience. What the student should strive to acquire is a knowledge of the principal securities and investments, and a *thorough knowledge of the characteristics and special points* connected with the various classes

into which the investments of a life assurance company can be divided. Burdett's "Official Intelligence" and "The Stock Exchange Year Book" are the great mines of information concerning Stock Exchange securities. The student should attend any available lectures on the subject of investments, and should read Gunn's "Stock Exchange Securities," and Nicoll's paper entitled "Description of Certain Stock Exchange Securities," as well as Clare's lectures already referred to. As regards investments made by way of loans, the proposal forms used by the office with which the student is connected should be carefully studied to see on what points information is deemed essential. The correspondence in such cases is also important. There are, in addition to the books and articles already mentioned, a number of papers in the "Journal of the Institute of Actuaries," and of the other insurance institutes, which should be read.

The Student's Library. The student will find it difficult and expensive to purchase all the books mentioned, especially the earlier numbers of "The Journal of the Institute of Actuaries." He will, however, be able to borrow some of them from the library of his office, and others from the library of the Institute; he can thus, in most cases, reduce his purchases to a minimum.

In endeavouring to indicate the work which the actuarial student has to do before he becomes fully qualified, we have kept in view principally those who are not familiar with the subjects dealt with. On this account an exhaustive list of reading has not been attempted, though nothing of importance has been omitted. For fuller information, including the papers in the various journals which should be read, the student is referred to an admirable article, entitled "Hints on Reading for Actuarial Students," which appeared in the "Post Magazine" in 1903 from the pen of a well-known coach.

The general aim of the Institute, and also of the Faculty, examinations appears to be to educate the student first in pure mathematics, next in the theory of Actuarial Science, then in the practical application of that science, and finally in various subjects not strictly actuarial, but a knowledge of which is nevertheless necessary to the actuary. The foundation of the whole scheme is mathematics, and parents who wish their sons to enter the actuarial profession should see that a considerable portion of their time at school is devoted to algebra, trigonometry, and kindred subjects; and, further, should not allow a lengthy period to elapse between leaving school and beginning serious work. This is too often allowed, and it is no exaggeration to say that in many cases it is fatal, for the habit of studying is broken, and much useful information forgotten in the interval.

As already mentioned, a certain aptitude is necessary. The examinations are far from easy, and great application is required to get through such an enormous amount of reading when the days are spent in an office and only the spare hours of the evening are available for study.

The Faculty Examinations. The first examination of the Faculty corresponds very closely with Part I. of the Institute examinations. The second differs mainly from Part II. of the Institute in that the History and Characteristics of Mortality Tables takes the place of the Principles of the Construction of Mortality Tables, and other tables involving the contingencies of life. The third examination involves all the subjects in Parts III. and IV., with the exception of "The Elements of the Law of Real and Personal Property," and "The Principles of Banking and Finance."

The subscriptions to the two Institutes are very reasonable. We give the figures:

THE INSTITUTE OF ACTUARIES

Probationer, entrance fee, 10s. 6d.; annual subscription, 10s. 6d.

Student, further entrance fee, 10s. 6d.; annual subscription, £1 1s.

Associate, annual subscription, £2 2s.

Fellow, annual subscription, £3 3s.

FEES for class in Part I. or Part II., £2 2s. per session, from October to April.

FACULTY OF ACTUARIES

Students, entrance fee, £1 1s.; annual subscription, 2s. 6d.

Associates, futher entrance fee, £2 2s.; annual subscription, £1 1s.

Fellows, further entrance fee, £2 2s.; annual subscription, £2 2s.

It is impossible to give an idea of what a tutor would charge for individual attention, but where the student is one of a private class the fee charged for a winter session for Part III. or IV. will be found not to exceed £10 10s., and for Part I. or II. will be considerably less. The fees charged by the London School of Economics vary according to the course, but will in every case be found very moderate.

Actuarial Work in the Office. Probably the first actuarial work which the student will be required to do in his office will be the calculation of ordinary rates of premium, surrender values, paid-up policies, etc. The formulas employed are all laid down in advance by the actuary of the company, and the work is therefore not particularly difficult. At a later stage will come special calculations in connection with risks of various kinds which do not proceed on definite lines, and are consequently of greater interest. There are also valuations of reversions and life interests, either for purchase or for the purpose of determining their suitability as security for loans. Statistical work in connection with various Government returns, and for office information, also falls on the actuarial staff. All these branches of work will be done under the supervision of the chief actuary, who will also be responsible for the preparation of new schemes, acceptances of risks, settlement of claims, valuation of liabilities and assets, the distribution of the surplus disclosed by the valuation, and, if he be also the manager, the investment of the funds of the company.

Continued

Group 2

GLASS

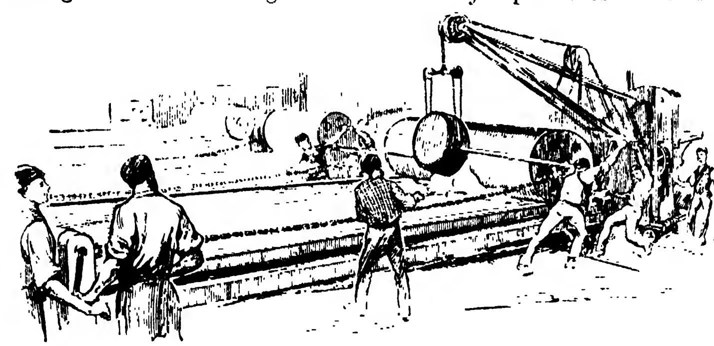
2

Continued from page 4534

PLATE GLASS AND BOTTLES

Making, Grinding, and Polishing Plate Glass. Perforated and Wired Glass. Blowing Bottles and Tumblers. Making Glass Tubes and Rods

Plate Glass. Plate glass is made by pouring molten glass on to an iron table, flattening it by passing an iron roller over it, and, after annealing the sheet of glass, grinding the surfaces flat, and polishing. The materials used are the purest obtainable, as freedom from colour is most necessary. The melting is done in pots, which serve also for pouring, the melted glass being for this purpose lifted bodily out of the furnace. The furnaces, on this account, are constructed with sliding doors made of iron frames, filled with firebrick, so that the pots can be readily taken out. The melting-pots having been filled with material, are lifted in place, the doors of the furnace closed, and the producer gas admitted. In about 15 hours the glass is ready for pouring. The door is then lifted, and a large wrought-iron balanced pair of tongs is swung into the furnace by a travelling crane. The pot is withdrawn and brought to the casting table. The casting table is a carefully



9. ROLLING PLATE GLASS

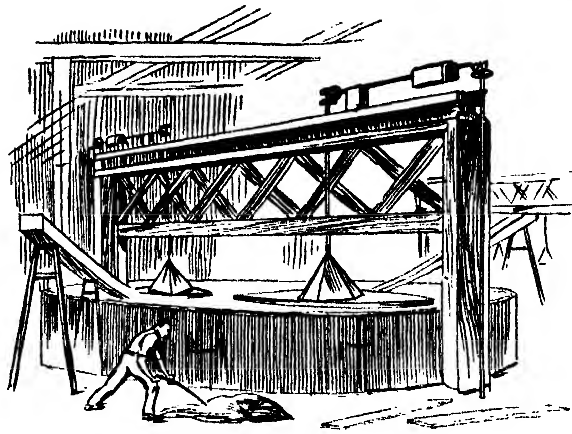
trued surface of cast iron or bronze. The surface is not in one piece, but consists of small sections, the object being to neutralise the warping which would take place if one large sheet of metal were heated on one surface only.

On one end of the table is a hollow cast-iron roller, extending entirely across the table. Down each edge of the table is laid a strip of iron, ½ in. in thickness, upon which the roller travels. Round each end of the roller is wound a chain, which is carried to the opposite end of the table to the drum of a hand winch. An overhead electrical crane carries a pot of molten glass up to the line of the annealing furnace, where it is set down and picked up by a small jib locomotive crane, which travels on a track that runs the full length of the annealing furnaces. By this crane the pot of metal is carried to the casting table, where the contents are poured out in front of the roller [9]. The roller is then drawn forward, and as it is raised above the table by half an inch, the molten glass is rolled out to just that thickness. By the time it has been rolled out the glass has cooled sufficiently to be moved to the annealing furnace. This furnace is raised to a temperature higher than that of the glass, and as soon as the plate has been introduced, the door is shut and the plate left to cool slowly for from four to five days. The cooling is assisted by passing cold air into flues below the annealing furnace.

Grinding the Plate. When removed from the oven, the plate is rough, and is submitted to the processes of grinding and polishing. The ½ in. plate in these operations becomes reduced to ¼ in., an ⅛ in. being lost from each side of the plate. The rough grinding is done between series of grinding tables arranged in groups of three, each group consisting of a lower and two upper tables. The lower table is a large cast-iron rotating disc, which has been faced and carefully trued up. The plate is laid upon this and embedded in plaster of Paris. Bearing upon the glass plate are two circular runners, one of which is 12 ft. and the other 14 ft. in diameter. The two runners are journalled in a trussed frame which extends across the top of the machine, and they are driven by means of mitre gears and shafting. The bottom face of the runners is shod with a number of parallel cast-iron serrated bars, which are spaced about 3 in. apart. The grinding [10] is started at slow speed, the runners moving at the rate of about two revolutions per minute. As it proceeds, the speed is increased until it reaches 30 revolutions per minute. Sharp sand and water are fed to the plate, and as not merely the runners, but the table below, are constantly rotating, the grinding is perfectly even over the whole surface of the glass, and thus a true surface is obtained. When about ⅛ in. has been taken off, the plate is turned over, and the rough grinding repeated on the opposite side. As the sand and water flow from the grinders, it is carried to a series of grading boxes and prepared for use again.

The Polishing Process. The plate, as it comes from the rough grinders, is like ground glass, and it is necessary to submit it to a polishing process. The polishing is done upon a large number of low tables. Down the full length of each table extends a cast-iron girder, to which is attached at intervals of about 20 in. a series of transverse wrought-iron bars [11]. Through the end of each of these bars extend the vertical

shafts of a series of felt-covered polishing discs. The pressure upon these discs is regulated by means of cup-shaped weights. which are placed upon their vertical spindles. The polishers are fed with rouge or oxide of iron, obtained by igniting sulphate of iron at a white heat for 36 hours. This rouge, mixed with water, is squirted on to the plate during the polishing operation. The longitudinal girders referred to above are connected to the crank-arms of a series of spur wheels driven by a 75-horse power engine, and by this means an oscillatory movement is given to the whole series of polishers. It takes twelve hours, six hours each side, to give the proper finish to a plate of glass. After polishing, the glass is sorted over for faults, and cut up into the desired size by a diamond.

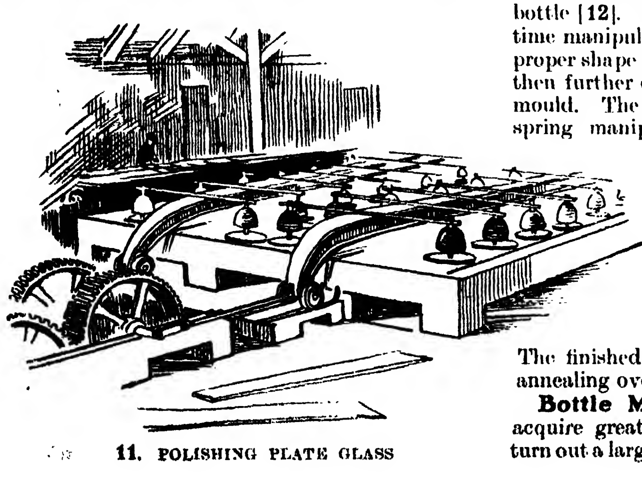


10. GRINDING PLATE GLASS

Rolled Plate. Unpolished plate glass is used for roofing purposes, but is frequently impressed with a design of fine lines, grooves, or squares, and in this condition is very largely used where obscured light is desired. The metal is ladled direct from the pot on to the table and rolled in the ordinary manner, but each ladleful is poured out at the end of the preceding quantity, as it is not so important in this case to avoid air bubbles. The rolled plate can also be annealed by piling on edge, as practised in annealing sheet glass, thus avoiding the use of the costly annealing furnaces required in the case of plate glass, where only one to three plates can be treated at a time. A method of making rolled plate practised by Messrs. Chance, of Birmingham, is to pass molten glass between a pair of rollers down an inclined plane. The glass is thereby rolled into a sheet, this sheet being then carried on an inclined plane to the annealing furnace. Additional rollers with patterns upon them are also employed. *Rippled glass* is made by the same firm by making the roller alternately rise and fall by means of a tooth edge on the side of the table.

Perforated and Wired Glass. A *perforated glass* for ventilating purposes is made on a casting table furnished with projections, so that on rolling holes are made in the glass, or the glass is so thinned at the spots that it can be easily drilled. The holes can be made by drilling with sand and water.

With the idea of increasing the strength of rolled glass, and preventing the scattering of the glass in case of breakage, it has become customary to enclose wire netting for certain kinds of glass. A layer of rolled glass of half the usual thickness is prepared; on this is spread the wire network, and then another layer of glass is rolled upon the netting. The wire is thus entirely enclosed and cannot rust. *Wired glass* is specially adapted for skylights, as wire protectors can be dispensed with. The glass is also to a certain degree burglar-proof, as it cannot be cut through with a diamond.



11. POLISHING PLATE GLASS

Bottle-making. The manufacture of glass bottles is a blowing operation, whether done by a workman or by a machine using compressed air. Moulds are used for shaping the bottle, and are made of cast iron or brass. A workman takes up on the blowpipe from the glass tank a sufficient quantity of the molten metal, called a *gathering*, and hands it to the "blower," who blows the mass into a pear-shaped bottle [12]. This embryo bottle is at the same time manipulated on a *marver*, and when of the proper shape is placed in the bottle mould and then further distended by blowing till it fills the mould. The mould is opened and closed by a spring manipulated by pressure of the foot. The bottle is released from the mould and separated from the blowing rod by touching the neck with a wet tool. A workman then forms the lip of the bottle by affixing a ring of molten glass which is moulded to the proper shape by a necking-tool, some varieties of which are shown in 13. The finished bottles are taken at once to the annealing oven.

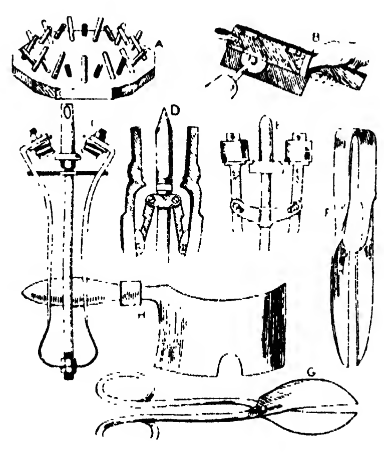
Bottle Machines. Although workmen acquire great dexterity in making bottles, and turn out a large number of these useful receptacles,

it is not surprising that efforts have been made to make the process quicker and surer by means of automatic machinery. Mr. H. M. Ashley in 1886 patented his bottle-making machine, which has since been modified and improved. Mr. Ashley's description of his machine is as follows: A quantity of molten glass is poured into a cup-shaped mould termed a *parison mould*, the lower part of which is made the counterpart of the shape which the head and neck of the bottle are intended to have. While the glass is still in a plastic state in the bloom or parison mould, a *punch* or *plunger* is pushed up into the body of the glass and withdrawn, thus forming a cylindrical cavity in the glass. The parison mould is then inverted and withdrawn, the neck mould, or that part which embraces the head and neck, being still left in position, so that the parison, or bulb of glass, remains suspended by the head and neck; this bulb, being still plastic and tending to elongate itself by gravity, is then enclosed within a mould which is a counterpart of the finished shape which the bottle is intended to have. Air or gas under pressure is then admitted into the interior of the glass bulb through a perforation in the punch or plunger, and the glass is thus distended so as to take the shape of the mould enclosing it. This mould being then removed, the bottle remains suspended by the head and neck, and that part of the mould being then opened the finished bottle is released and is conveyed away to be annealed.

12. GLASS-BLOWING

Several sets of apparatus are arranged on a revolving frame provided with means of performing successive movements automatically.

Since Mr. Ashley's machine was introduced, many variations have been brought out by other inventors, most of them being equally adaptable for narrow-necked bottles and wide-mouthed jars.



13. GLASSWORKERS' TOOLS
a. Northwood's scolloping tool for shaping edges of vases *b*. Richardson's wineglass foot mould, "Pacella" *c*, *d*, and *e*. Three forms of tongs for shaping the necks of bottles (*c* shows the complete tool) *f*. "Tool" for regulating the form of a blown glass vessel *g*. Shears for trimming edges of vessels *h*. The "whip," for forming necks and cleaning away surplus glass

Blown Glass. By a combination of blowing and clever manipulation with simple tools [13], the glassblower forms variously shaped vessels out of molten glass. Table glass, except the commonest, is blown glass. A *tumbler* is a simple form of the glassblower's art, but in making it a special rotary motion is given either to the blow-tube or the mould, which requires considerable practice. A *wineglass* is a more elaborate production. The bowl is first made, the stem and the foot being subsequently added and shaped.

Pressed Glass. Another form of hollow glassware is that known as *pressed glass*, which is made chiefly at Gateshead in England and Pittsburg in the United States. The glass used is *flint glass* (lead glass) on account of its superior brilliancy, but the cheaper *baryta glass* is being increasingly employed. The process is manipulated by either hand or steam, the small hand presses being sufficient for small articles. The moulds are of iron or gunmetal, and a quantity of molten glass having been introduced, a plunger descends and forces the glass into all parts of the mould, thus shaping the outside and the inside of the vessel at the same time. The Appert process is a modern development in the manufacture of pressed glass which seeks to overcome the cooling effect of the mould, and to make the process automatic. The moulding is effected by successive stages so that the glass only touches as small a surface of metal at one time as possible.

Fire Polishing. The surfaces of the pressed glass article are not so smooth as blown glass, but this defect is overcome by what is known as *fire polishing*. This consists in reheating the articles in an oil furnace with a steam blast so that the outer surfaces of the glass are melted, a brilliant surface being the result. The method was invented by Sowerby in 1886, and improved in 1896. The furnace receives the heat from injectors at one or both ends, the glass article being held on a *snap*, which has the ends lined with asbestos to prevent cracking.

Glass Tube and Rod. Tubing or rod of glass is made by gathering metal on a blowpipe, rolling it on the marver, attaching a metal rod to the opposite side of the lump of glass, and drawing the two rods apart. If the lump of glass has been formed into a hollow bulb, tubing results. The rods are held by different workmen, who walk backwards away from each other, assistants watching the process to give warning of any thinning of the tube in parts. Glass buttons are pinched off glass rods while still soft, the pincers having moulds on the gripping surfaces. Glass marbles are also cut off glass rods while soft, but are then placed into an iron drum with kaolin and rapidly revolved, when the pieces of glass assume globular shape. A recent application of glass rod is seen in the prismatic globes used for covering electric light bulbs. The glass rod is softened by a blowpipe flame, and coiled upon a revolving mandrel of the required form. Glass tubing is used in the manufacture of beads, a short account of which is given in the next lesson.

Continued

PROBLEMS IN THE CONE

Effects of Height. The Shapes of Envelopes. Conic Frusta. Oblique Cones. Effect of Varying Planes of Truncation. Plates for Fire-boxes

continued from page 4526

By JOSEPH G. HORNER

CONICAL figures and portions of the same divide importance about equally with pyramidal forms, and they occur in right and oblique varieties. Their construction is not difficult, either by direct reference to the apex or by the method of triangulation.

The Elements of the Cone. In **41**, AB is the vertical height of the cone, AC its slant height, BC its radius, and DE the diameter of its base. Hence the meaning of the statement that a right cone is formed by the revolution of a right-angled triangle round one of the sides contained in the right angle, and that the hypotenuse in its revolution develops the surface of the cone.

In **42** and **43** the triangle is dotted on one side of the axis and the cone drawn on the other. The axis of revolution, therefore, is the side *a* in **42**, and the side *b* of the triangle in **43**. The hypotenuse *c* measures the same length, *c*, in each case, but the difference in the diameter of the base and the difference in the steepness, or slant height, and the vertical height are most marked. Not the least value of an object lesson like this is to introduce a mental exercise which the workman constantly finds himself making. When in doubt about the possible resulting shape of a development, greatly exaggerate it mentally, and the issue often becomes obvious.

To obtain one dimension from others, lay down the known dimensions to scale, or to full size, and measure off the others. Thus, in **42** and **43** the heights *de* and radii *ef* being known, the length of the slant edge, *df*, is obtainable. Or, if radii *ef* and slant *df* are given, the heights *de* can be obtained. The construction is too obvious to need further description, and of course the same method applies to conic frusta.

Cases arise in which it is not practicable to draw the entire triangle, and then the rules of geometry may be used thus: if the lengths of the sides be known, add the squares of these, and the square root of the sum will be the length of the hypotenuse. The lengths of the sides are the equivalent of the perpendicular height, and the radius of the base of a cone and the hypotenuse is the equivalent of the slant height.

It is not necessary in all right circular cones to draw the circle of the base in plan, as it was essential to draw the base of a pyramid in plan in our first article. The bases of **42** and **43** are circles of radii *ef*, *ef*, which we know must be the case. But in many cases it is necessary to draw the circle, not to obtain the shape, but to get other dimensions and relations on.

Marking Out the Envelope of a Right Cone. In marking out the complete envelope of a cone, therefore, the length of the slant edge *c* [**42** and **43**], or AD, AE [**41**] is taken for a radius, the length of the circular edge of the envelope is made equal to the circumference of the base, and lines are drawn from the termination to the centre, corresponding with the apex, thus:

Taking the cone in **42**: To obtain the length round the circumference, calculation based on diam. × 3·14159 is not so convenient as stepping round with a large number of very short chords, because of the difficulty of bending a rule round. These steps of division may be as numerous as desired. The distance round *f* is more conveniently obtained by drawing a quadrant of the circle, as in **44**, or a semi-diameter, as shown below **42**, and dividing either into any convenient number of equal parts. Four times the number of divisions in the first [**44**], or twice the number in the second [**42**], will give the total length round the circumference of the base of the cone. The larger the number of divisions the more nearly will the chord measurements be the equivalent of arc measurements. Now, these divisions have to be stepped round an arc, not of radius *ef* [**42**], but of radius *df*, as in **45**. Then, starting from *f* [**45**], step round 16 parts and connect the sixteenth with *d*, and the envelope is obtained which will cover the cone in **42**.

Just to fix this in the mind, see what the development of **43** would give us. Divide a quadrant of **43** into, say, 10 equal parts as shown. With the slant height *df* for radius, strike an arc [**46**], and divide it round four times 10, and connect the fortieth division with *d*. The resemblance to the development in **45** is hardly obvious. We learn, therefore, that the flat cone cuts into more material than a steep one, for the sheet is almost a complete disc. The relations between slant height and vertical height are also much more apparent than in steep cones.

The Conic Frustum. The envelope of the frustum of a cone is obtained by the same kind of construction as that of the complete cone. In **47** the elements of a conic frustum are shown, with the cone of which it forms a section completed by dotted outlines, in order to determine the shape and proportions of the frustum.

In **47**, AB is the perpendicular height of the cone, and B*b* that of the frustum. BC is the radius of revolution of the base, sweeping round the diameter DE; *bc* is the corresponding radius in the plane of truncation, sweeping the diameter *de*. The slant height of the complete cone being AE, that of the frustum is *e*E. We have therefore two planes, DE and *de*, separated by

a slant dimension *e*E, for which the circumferences of the sheet to form the envelope have to be obtained, as in **48** and **49**, thus:

Draw the required frustum, D*de*E [**48**], and complete the cone to the apex A. Take the slant height AE as a radius, and strike a circular arc [**49**], with radius AE. Take the radius BE of the base of **48**, and strike a quadrant E*f*, and divide it into any convenient number of parts, say six. Transfer these four times in succession to the curve E in **49**, which will then be practically equivalent in length to the circumference of the base DE in **48**. Connect EA24 [**49**], which will complete the boundaries of the entire conical figure in **48**. As the article required is for the envelope of the frustum, it is only necessary to take the curve corresponding with the plane of truncation from the slant edge, and carry it as far as the radial lines, so completing the envelope without any dividing round. Thus the slant height A*e* [**48**] is taken, and a curve *ed* struck from A in **49**. The sheet E*ed*24 in **49** will be the correct envelope for the body of the frustum in **48**. The bottom and top are obviously circles of diameters DE and *de* respectively.

The developments represent the exact envelopes only, to which extras for joints, soldered, riveted, or otherwise, as the case may be, have to be added on the completion of the exact developments.

A Frustum with a Distant Apex. Taking next an article [**50**] in which a conical frustum occurs, where the apex would be situated at too long a distance away to admit of the use of compasses, the triangulation method illustrated in our first lesson again comes in. Such problems occur very frequently, both in complete figures and in the curved corners of flaring objects, or those having sloping sides or "flue."

Figs. **51, 52** show the marking out of the pattern for the frustum in **50**. First take the radii A, B from **50**, and strike them both in plan [**51**] from centre, *o*. Divide a quadrant on A into any convenient number of equal parts, and prolong lines thence to the centre, *o*, cutting the curve B so that both arcs A and B are divided proportionately. These divisions correspond with those of quadrants of the circles of the base and the plane of truncation in **50**; but we now have to obtain the width corresponding with the slant face C in **50** and the curves of the developed plate, obtained thus:

Raise a line [**51**] *a*D, perpendicular to the line A*a* joining the points A*a*, and measure off on it the length *a*D, equal to the perpendicular height D in **50**. Join AD, which will be the actual length of the line A*a*, measured up the slant face C in **50**.

From these the plate is developed as in **52**. Draw a line AB equal in length to the slant height C [**50**]. Take the divisions A1, B*a*, in **51**, and set them off by small arcs A1, B*a*, in **52**. Take the length AD in **51** for a radius, and from the points A and B in **52** as centres strike arcs intersecting those, 1 and *a*, just marked. Next, taking 1 and *a* as centres, proceed as just described from A and B, striking arcs with radius AD [**51**], repeating the process from each new set of centres obtained, as 2 and *b*, 3 and *c*, 4 and *d*, 5 and *e*, to 6 and *f*. Curves drawn through the successive centres as shown will give the outline of the sheet required. Fig. **52** is, of course, only a quadrant, which has to be repeated four times to produce the entire envelope for **50**.

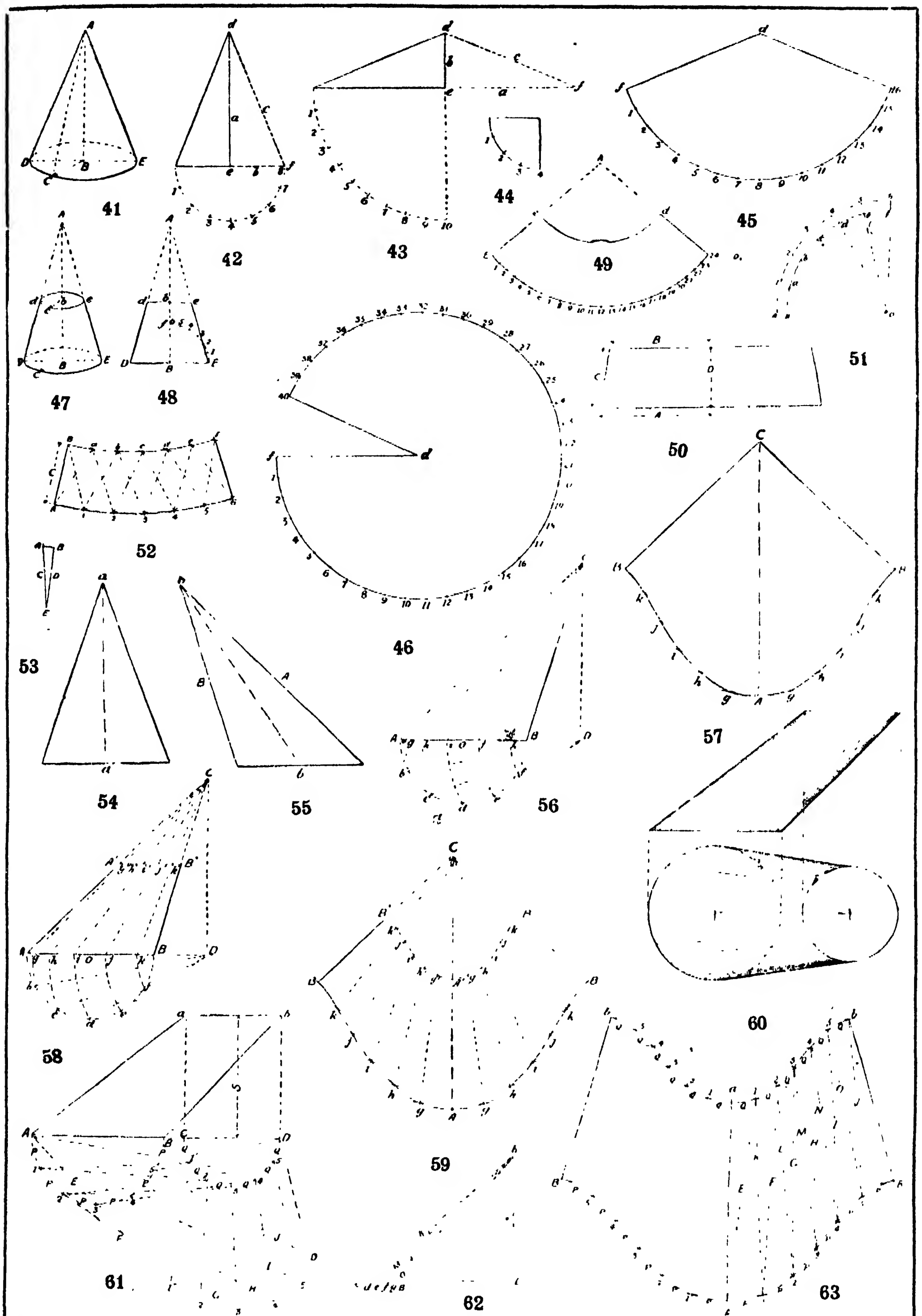
It may often happen that the vertical height only, D [**50**], of the conic frustum is known, and not that of the slant C. Then the latter can be obtained as in **53**. The distances corresponding with the difference in radii on top and bottom being given, AB, a line BE is raised perpendicularly to a line connecting the radii. The length BE is measured off equal to the perpendicular height D, in **50**, and a diagonal AE will give the slant height C.

Oblique Cones. Oblique cones are those in which the apex is not situated over the centre of the base. As, therefore, the right cone is developed by the revolution of a hypotenuse of constant length and angle round one side of the right angle, so the oblique cone is the result of the revolution of a hypotenuse of *varying* length round angles that vary constantly. Two views of an oblique cone are shown by **54** and **55** taken at right angles to each other. Only on opposite sides of the plane *aa* do the angles and lengths correspond. On the opposite sides of the plane *bb* there is an infinite gradation from the maximum slant A to the minimum ditto B.

Oblique cones are drawn by the same principle as the oblique pyramids in the previous lesson. In fact, if we regard a cone as a pyramid with all the angles obliterated, the construction is identical. In drawing cones, divisions and lines are taken at intervals just as in pyramids.

To develop the envelope of a complete cone [**56**] let AB represent the base of the cone, C its apex, and O the centre of the base. From O as a centre describe a semicircle of diameter AB. Divide this into any convenient number of parts, as shown. Drop a perpendicular from C to meet the line AB, prolonged at D. Draw lines from *b*, *c*, *d*, *e*, *f* to D. These will represent the cone divided in plan. Using D as a centre, draw radii from *b*, *c*, *d*, *e*, *f* to cut the line AB at *g*, *h*, *i*, *j*, *k* respectively, and join *g*, *h*, *i*, *j*, *k* to the apex C. The lines C*g*, C*h*, C*i*, C*j*, C*k* are the actual lengths of the lines *b*D, *c*D, *d*D, *e*D, *f*D respectively drawn in plan, and are therefore the working lines.

Fig. **57** shows the development of the envelope, supposing the seam to occur along the line CB in **56**. From a centre C [**57**] strike radii CA, C*g*, C*h*, C*i*, C*j*, C*k*, CB equal respectively to the radii similarly lettered in **56**. Take in **56** the distance A*b*, or *bc*, *cd*, etc., these divisions being equal, and set off the same distances from A to *g*, *g* to *h*, *h* to *i*, etc., to B and B in **57**. Join B and B to C to obtain the sides for the seam, and draw a curve through the various points of intersection, as shown, to produce the envelope corresponding with the base.



THE CONE AND ITS DEVELOPMENT

41. Elements of the cone 42, 43. Effect of difference in heig'' of cones and envelopes of same 44, 45, 46. Stepping round chord divisions for lengths of arcs 47. Elements for conic frustum 48, 49. Envelope of conic frustum 50. Conic frustum with little slant 51 52. Envelope obtained by triangulation 53. Problem when the slant is not known 54, 55. Oblique cone 56, 57. Envelopes of oblique cones 58. Truncated oblique cone 59. Development of truncated oblique cone 60. Cone with apex inaccessible 61, 62, 63. Envelopes of cone with apex inaccessible

Truncated Oblique Cones. Truncated cones also may be cut both at base and top, parallel with the true base of the cone, or, as is frequently done, at an angle therewith. They may also be developed with compasses, or by triangulation. The cone may also vary much in its degree of obliquity, until one side may stand vertically.

If the frustum be truncated in a plane parallel with the base, the projection of the lines from the base to the plane of the truncation gives the radii at once for a second set of arcs, drawn in **58**. Also a semicircle equal in radius to that at the plane of truncation, divided round into the same number of equal parts as the base gives the points of division on the corresponding arcs, through which the curve of development is drawn for the small end of the frusta thus:

In **58** let AA′B′B be the elevation of the frustum. The construction of the development of the base is the same as that shown in **56** and **57**, and the same reference letters being employed in the two figures, it is not necessary to repeat the instructions there given. The *additional* lines required for the construction of the top of the frustum are obtained thus: The lines which pass from the points of division in the base to the apex cut the plane of the frustum at the points *g*′, *h*′, *i*′, *j*′, *k*′ [**58**], and the lines thence to the apex C give the true lengths of the several generating lines in the frustum. To obtain the developed form, mark the curve for the base as shown in **59** similarly to that shown in **57**. Then for the curve for the top of the frustum; with the radius CA′ [**58**], strike the curve CA′ [**59**]; with the radius CB′ [**58**], strike the curve CB′ [**59**]; and so on with the radii C*g*′, C*h*′, etc., in **58** transferred to **59**. Through the points of intersection of these arcs with the radial lines previously obtained draw the curve B′A′B′, then the outline BAB B′A′B′ will be that of the development of the frustum.

The so-called oblique truncated cone occurs frequently. Its chief value lies in connecting cylindrical bodies, the axes of which are not perpendicular, hence the base and plane of truncation are generally circles. If a right cone were tilted, and its base and top cut at an angle, the section would be an ellipse, as we shall see later, and then the plans would have to be developed as ellipses. But in speaking of oblique cones, the base and truncation, when parallel with the base, are taken as circles. These relations are shown in **60**, where the plan of base and top are drawn perpendicularly to their elevations. We see also that the degree of slant may often be such that the apex might be inaccessible, so that the method of **58** could not be applied. We now take, therefore, such a case and show its development without radii from the apex.

Conic Frustum with Distant Apex. To obtain the pattern for such a frustum, first proceed as in **61**. On a base line draw semicircles AB, CD, equal in radius respectively to that of the base AB and truncated top of the cone *ab*, the latter being perpendicular from the top as shown. If angles of slant only are given, draw lines A*a*, B*b*, and draw the semi-diameters thence. Divide these semi-diameters into any convenient number of equal parts, 1, 2, 3, 4, 5, B, 1′, 2′, 3′, 4′, 5′, D, taking care that the number of divisions shall give a central division, as 3′3′. Connect these points of division by lines 1 1′, 2 2′, 3 3′, 4 4′, 5, 5′. These will represent the lengths of lines of development in plan, but they are obviously not the actual lengths required for setting out the pattern. The lengths of the sloping edges A*a* and B*b* are those taken directly on the elevation. But as the actual lengths of the lines 1 1′, 2 2′, 3 3′, 4 4′, 5 5′ are not the same as those drawn in plan, they must be obtained by projection to the elevation, thus:

As the point D is dropped perpendicularly from *b*, the length DB bears the same relation to the slant length B*b* that the lengths of the lines 1 1′, 2 2′, etc., do to their real lengths. Thus, starting from D as a point to mark from [**62**], take the length 1 1′ from the plan [**61**] and set it off from D to *c* [**62**]. Then *cb* will be the real length of 1 1′. Next take 2 2′ from the plan and set it off from D to *d*, and *db* will be the real length of 2 2′, and so on, to get the positions *e*, *f*, *g*.

To obtain the true diagonal lengths required for triangulation [**61**]. From 1′ draw 1′1″ perpendicular to A1′, and measure off 1′1″ equal in length to the height S of the frustum. Then the length A1″ will be the true length of the line A1′. Also, having connected 2, 3, 4, 5 to 2′, 3′, 4′, 5′, from 2′, 3′, 4′, 5′, D, draw lines 2′2″, 3′3″, 4′4″, 5′5″, DD″ perpendicular to 1 2′, 2 3′, 3 4′, 4 5′, and 5 D, respectively, and all equal in length to the height S. Joining 1 2″, 2 3″, 3 4″, 4 5″, 5 D″ will give the true diagonal lengths required for triangulation.

Envelope of Frustum. We have now, therefore, the true lengths [**62**] of the lines of division taken on the planes of the semicircles for base and crown. Also the real lengths of the diagonals in **61** required for setting out the development by triangulation.

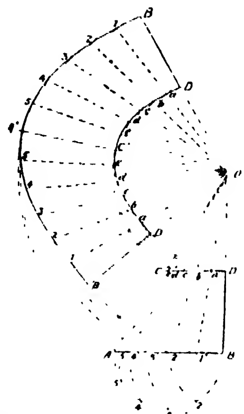
To describe the envelope [**63**], draw the line A*a*, equal in length to the line A*a* in **61**, and use A and *a* as centres, as follows. (But as it is very confusing to bear all these letterings in mind, capital letters are introduced in addition, to represent the lines themselves, so that by comparing those in **61** and **62** with **63** the corresponding relations are seen at a glance.)

From A as a centre [**63**] with the radius A1″ [**61**] (length E), strike an arc. From *a* as centre and with radius C1′ [**61**] (length Q) strike an arc cutting this at 1′ [**63**]. Then from A as centre and radius A1 [**61**] (length P) strike an arc; and from 1′ as centre, and radius *cb* [**62**] (length K) strike an arc cutting this at 1 [**63**]; 1 and 1′ [**63**] are now new loci or points of intersection whence 2 and 2′ are obtained from the next pair of elements in **61** thus: From 1′ [**63**] as a centre, and radius 1′2′ (length Q) [**61**] strike an arc. From 1 [**63**], with radius 1 2″ (length F) [**61**], strike an arc intersecting this at 2′ [**63**]. Then from 2′ [**63**] with radius *db* [**62**] (length L) strike an arc [**63**], and from 1 with radius 1 2″ (length F) [**61**], strike an arc intersecting this at 2 [**63**]. Then 2 and 2′ are points of intersection from which with respective radii 2 3″ and 2′ 3′ [**61**] the

next points of intersection, 3 3′ [63], are found. From 3′ and 3 as centres, and respective radii *eb* [62] (length M), and 3 4″ 4′ [61] (length H) describe arcs intersecting at 4 4, and so on until the figure required is completed, the pattern being symmetrical about the centre A*a*.

Oblique Cone with One Side Vertical. A variation in the oblique cone occurs when one side is perpendicular, BD in **64**. Draw a semicircle on the base AB, and divide it round equally as convenient, 1, 2, 3, 4, 5, A. From B as centre strike radii from these points of division to cut AB at 1′, 2′, 3′, 4′, 5′. Prolong these lines to the apex *o* of the completed cone, cutting the plane of truncation CD at *a, b, c, d, e*. The developed pattern is shown to the left in **64**, obtained as follows:

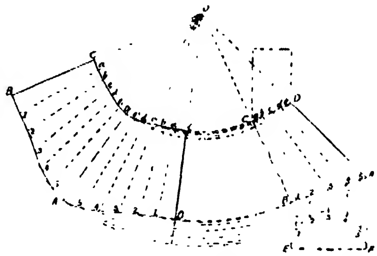
From *o* as a centre, draw arcs starting from A, 5′, 4′, 3′, 2′, 1′, B, and another series of arcs from C, *e, d, c, b, a*, D. Set the compass to one of the equal divisions 1, 2, 3, on the semicircle, and from A′ as a centre step off these divisions from one arc to that adjacent in the manner shown, 5, 4, 3 etc., and the edge of the envelope corresponding with the base is then drawn through these points of intersection. Prolong lines from all these points of intersection to the centre *o*. For the edge of the truncated face, the points of intersection of the radial lines just drawn, with the successive circles *e, d, c, b, a*, will give the required development, the edges BA′BDC′D completing the outlines



64. OBLIQUE CONE WITH ONE SIDE VERTICAL

Different Planes of Truncation. Conic frusta are often cut both along the base and along the plane of truncation in planes that are neither horizontal nor parallel. To draw the envelope of an oblique conic frustum ABCD [**65**], to join two vertical cylinders, proceed as shown, the cylindrical portions being indicated by dotted outlines.

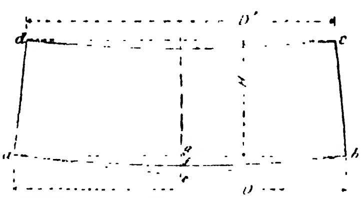
In the lower portion draw a semicircle, EF, to represent half the lower cylinder in plan, and divide it round into any number of equal parts, 1, 2, 3, 4, 5 and F. Project lines up from these to cut the base of the cone at the line of its joint with the cylinder 1′2′3′4′5′. Prolong lines from these points to the apex, *o*, of the cone completed, intersecting the plane of truncation CD, or that where the upper cylinder is to be united, at *a, b, c, d, e*.



65. ENVELOPE FOR VARYING PLANES OF TRUNCATION.

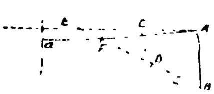
Now, from the apex *o* as a centre, draw arcs from these lines of intersection on both planes, starting from all the points of intersection, and the bounding lines, as B, 1′, 2′, 3′, etc., C, *a, b, c*, etc. Draw a centre line *o*A, anywhere [left hand of **65**], and to right and left of this step off distances A, 5, 4, 3, etc., equal to the divisions 1, 2, 3, 4, 5, on the semicircle EF. Draw radial lines thence to *o*. Through the successive points of intersection of the radial lines and curved lines draw the curves of the envelope at the large and small ends, as shown on left.

Conical Fire-boxes. Some problems in constant use differ from the foregoing in the fact that the amount of slant or taper is very slight, amounting to 3 in. or 4 in. difference in diameter at top and bottom. Neither trammels nor triangulation are adaptable in these cases. Two rules in regular use are here given for the plates of conical fire-boxes. One is shown in **66**. First set out the lengths D, D′, equal to the circumference of the plate required to complete the fire-box, on the lines *ab, dc*, the distance H, by which these lines are separated, being equal to the height of the fire-box. To obtain the top and bottom curves, first draw two lines starting from the edges *a, b*, and perpendicular to the edges *ad, bc*, meeting on the centre line at *e*. A point *f*, taken nearly midway between *e* and *g* will be a point in the curvature required for the bottom edge. It is often taken midway, but is more accurate if *f* be brought nearer to *g* than *e*, in the proportion of 4 to 5. The curve is drawn by bending a strip through the points *a, f, b*, and the top curve is afterwards drawn parallel with the first. Width of seam for riveting is added to *ad* and *bc*.



66. DEVELOPMENT FOR A CONICAL FIRE-BOX

Fig. **67** shows another method. From a centre A, with a radius less than one-fourth the length of the shorter edge of the plate, strike a quadrant BC. From B, with the same radius cut BC in D. Draw a line BE through BD. From D, and still with the same radius, cut BE in F. A line drawn from A, through F, cutting the centre line at *a*, will give the middle point in the curve required. The other edge will be cut parallel with the first as in the alternative method described in the preceding paragraph.



67. ANOTHER METHOD OF **66**

Continued

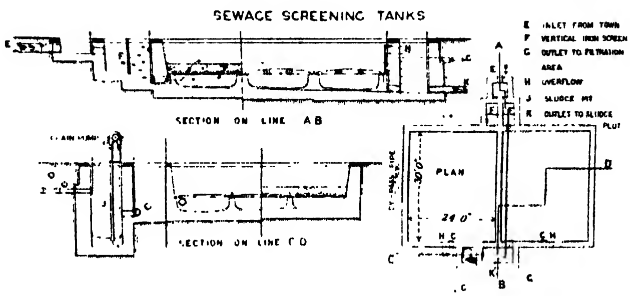
BACTERIAL TREATMENT OF SEWAGE

Various Bacterial Systems and What They Have Taught. The Contact System and Contact Beds

By Professor HENRY ROBINSON

THE bacteria which effect the purification of sewage are divided into two classes, (1) the aerobe, which requires air; (2) the anaerobe, which acts without air or light. The latter liquefies the organic solid matter in sewage as is seen in the ordinary cesspool, where only inorganic solid deposits will be found when it is cleaned out. The writer had an experience of this when he had to dispose of the sewage of a town on too small an area of land for irrigation to be possible. He wished to avoid the expense of chemical precipitation, and adopted an upward filtration system, by which the solids were arrested before the sewage passed on to the land. The diagram [38] shows the filter as actually carried out.

It will be seen that the tanks had false bottoms, covered with a bed of coarse stones. The sewage from the outfall passed slowly upwards through the filter, leaving the larger suspended solids in the false bottom, where they became liquefied by what is called *septic action*, as in a cesspool. The liquid sludge was pumped at intervals out of the bottom of the tanks, carted away, and disposed of on adjoining land with excellent agricultural results.



38. UPWARD FILTRATION SYSTEM

In designing a sedimentation tank, through which the crude sewage is to pass to deposit inorganic (and some organic) solids before the liquid is applied to bacteria beds, the capacity of the tank must be such as to insure no excessive velocity whereby the solids would be carried through it.

Bacterial Systems. The organic solid matters in suspension, or pseudo-solution, which flow from the sedimentation tank (after passing a screen to arrest large solid matters) to the bacterial beds are those which have to be acted upon by either aerobic or anaerobic germs, and the systems which have been adopted to perfect their action and to convert foul fluid into a good effluent will be described.

In 1895, Mr. Cameron, of Exeter, brought into prominence the results which he had obtained there by passing crude sewage through a septic tank, by which the solid organic matters were liquefied as already described. This form of tank was closed, but experience has shown that an open tank will enable the liquefying organisms to act. The point of admission of the sewage into the tank should be below the top of the fluid in the chamber, and the resultant septicised liquid should be drawn off at a point below the top level. A scum forms on the surface, which it is useful to preserve, and the writer, in employing tanks of this kind, has adopted a simple covering to protect the scum from the action of the wind and rain.

Birmingham Experience. An interesting paper was read in 1906 by Mr. Watson, of Birmingham, before the Incorporated Association of Municipal and County Engineers, in which he gives the liquefying action of septic tanks on the solids of the sewage of Birmingham. The composition of the sewage was as follows:

Dissolved Solids.	Suspended Solids. Total.	Suspended Solids. Organic.	Free Saline Ammonia	Albuminoid Ammonia.	Chlorine.	Nitrates and Nitrites as Nitrogen.	Oxygen Absorbed. Unfiltered.	Oxygen Absorbed. Filtered
119·3	74·3	44·9	4·05	1·57	20·2	0·92	27·56	15·79

He found that the sludge from the septic tanks was practically inodorous, but on being pumped on to the land it had to be mixed with earth in a ratio of one-fourth of the residuum to black earth before a satisfactory crop could be grown. It was also found that if the roughing tanks, which are provided to get rid of the detritus, were of such capacity as to sediment too much of the solids, the septic action in the tanks following them suffered, and it was necessary to pump a volume equal to 30 per cent. of the liquid sludge from the roughing tanks into the septic tanks daily to restore their fermentative quality. With the Birmingham sewage it was found that only about 10 per cent. of the sludge—which is considerably below the results at Manchester and other places—was liquefied in the septic tanks. It must, however,

be borne in mind that these places have a considerable quantity of trade waste to deal with, and it has been proved that with purely domestic sewage this percentage would be considerably augmented. • The chief point, however, that requires attention appears to be the condition of effluent coming away from the septic tanks. In order to get the maximum liquefaction of the solids it becomes necessary to have a very foul effluent coming away from the tanks, owing to the flow through the tanks being slow, thus tending to make the treatment of the same a danger as far as nuisance is concerned. The resultant sludge, however, as has been shown, is not offensive. If, on the other hand, a highly septicised sewage be not obtained, the sludge is more offensive, and greater care must be taken in dealing with it.

Contact System. In a paper before the same association, Mr. Dibdin dealt with the purification of sewage on biological lines by means of "contact" beds (referred to hereafter) filled with slate debris, supported on suitable slate blocks, the distance between the slates being about 2 in. He claims that a bed filled on this principle doubled its holding capacity, while the accumulations of mineral matter, which clog bacteria beds of clinker, stones, etc., can be flushed from the surfaces of the slates, and the bed restored to its original capacity. At Devizes, where some experiments were carried out, the capacity was found to be 87 per cent. of the total holding capacity of the beds. After 14 months this was reduced to 50 per cent., which, after being hose-flushed, was again increased to 82 per cent. It will thus be seen that beds filled on this principle have a very much greater holding capacity than with contact beds filled with ordinary clinker. It does not, however, appear practicable on a large scale, as the flushing of the beds would be almost impossible.

In covering a septic tank care must be taken to ensure ventilation, as the bacterial changes which take place in the sewage from anaerobic action liberate marsh gas, which is liable to explode, as has been the case in several instances.

GOVERNMENT HOUSE EXPERIMENTAL BACTERIAL INSTALLATION.

Areas and depths of filter material in filter beds, and amounts of tank effluent passed through beds in connection with samples taken for the purpose of analysis on May 28th, 1902.

No. of Filter	I.	II.	III.	IV.	V.		VII.
Area in sq. ft.	18½	18½	18½	18½	18½		42¼
	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
Depth and class of filter material beginning at bottom	0 3a	0 3d	0 3a	0 3d	0 3a	0 3d	0 3d
	0 3b	0 3e	0 3b	0 3e	0 3b	0 3e	0 3e
	2 6c	2 6f	2 6c	2 6f	2 6c	0 6f	1 0e
	—			—	—	1 10c	1 6g
	—			—	—	0 2f	
Total depths	3 0	3 0	3 0	3 0	3 0		

Material a is clinker passed by $\frac{7}{8}$ in. mesh and held by $\frac{5}{16}$ in. mesh
b ,, ,, ,, ,, $\frac{5}{16}$ in. ,, ,, ,, ,, $\frac{1}{8}$ in. ,,
c ,, ,, ,, ,, $\frac{1}{8}$ in. ,, ,, ,, ,, $\frac{1}{16}$ in. ,,
d ,, bluestone ,, ,, $\frac{7}{8}$ in. ,, ,, ,, ,, $\frac{5}{16}$ in.
$\frac{1}{16}$! $\frac{1}{8}$ in.
f , $\frac{1}{16}$ in
,, g ,, fine yellow sand free from all foreign matter.

Australian Experiment. The Australian Government had some valuable experiments carried out with the sewage of Perth, Fremantle, and the various suburbs under their chief engineer, Mr. Palmer. The results were communicated by him to the Public Health Engineer in 1905. The sewage was described by Mr. Mann, the Government analyst, as being of a far higher strength than would usually be found in a town sewage, while the percentage of purification was higher than he had seen recorded. The preceding table shows the construction of the seven filter beds that were used for the experiments.

On the day when the samples were taken for analysis the volume of sewage that was being delivered to the beds was noted as follows:

No. of Filter.	Gallons passed through the filter on May 28th, 1902
I.	110
V.	120
II.	120
III.	120
VI.	90
IV.	120
VII.	50

Bed No. 1 was used from 7 a.m. to 8.30 a.m., and again from 3 p.m. to 4 p.m. Two samples of bed No. 1 were therefore taken.

Beds Nos. 5 and 6 are kept as reserve beds and are used when one of the regular beds fills before its proper time.

Bed No. 5 was used between 8 30 a.m. and 9 a.m. and, not being full, was again used between 10 a.m. and 11.30 a.m. before being let off and the first sample of filtrate taken.

Bed No. 5 was used again from 4.10 p.m. to 5 p.m. and, after standing full, a second sample was taken from this bed.

Bed No. 6 was used between 12.30 p.m. and 1 p.m. and, not being full, was used again between 2.30 p.m. and 3 p.m. before being let off and a sample of filtrate taken.

There are, therefore, two samples of bed No. 1, and also of bed No. 5, and one sample each of beds Nos. 2, 3, 4, 6, and 7. [See table on next page.]

The result of much observation at different outfalls where tanks have been employed to work on the septic principle leads to the conclusion that their capacity should be sufficient to hold from one to one and a half days' dry weather flow.

Hydrolitic Tank. At Hampton-on-Thames what is called a *hydrolitic tank* forms a useful part of the system that has been adopted for the bacterial treatment of sewage, the Shone Ejector being used to collect and deliver the sewage at the outfall.

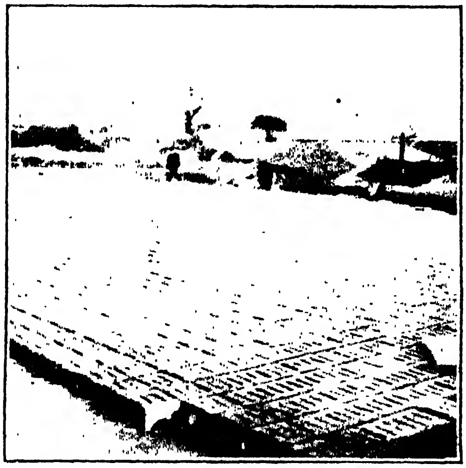
The sewage, after leaving detritus tanks, enters the centre of a transverse channel, which conveys it into the sedimentary chambers of the hydrolitic tank, which consists of two parts. The first portion is divided into three compartments by means of light division walls formed of flagstones. Of these compartments, the two outer are the sedimentary

SUMMARY OF AVERAGES.

Ultimate results are shown in heavy figures.

	Sewage.	Effluents.	Filtrates.	Percentage of purification effected. Effluent on sewage.	Filtrate on effluent.	Filtrate on sewage.
Oxygen consumed						
3 Minutes	12·02	1·34	·19	88·8	85·8	98·4
4 Hours	23·71	4·48	·39	81·1	91·3	**98·3**
Solid matter in:						
Suspension	264·88	9·26	1·87	96·5	79·8	**99·3**
Solution	62·30	43·95	40·76	29·4	7·2	34·5
Total	327·18	53·21	42·63	83·7	19·8	87·0
Ammonia:						
Free	12·25	3·81	1·18	68·9	69·0	90·3
Albuminoid	10 50	·989	·158	90·5	83·8	**98·4**

chambers and the central the liquefying chamber. Along the bottom of the sedimentary chambers are narrow openings which lead into the liquefying chamber, and form the only means of liquid communication between these chambers.



39. FALSE FLOOR FOR BACTERIA BED

False Floor for Bacteria Beds. Messrs. Stiff make a false floor for bacteria beds with channels to carry off quickly the fluid that has passed through the bed to the bottom of it. **Fig. 39** shows one of these in course of construction. It will be seen that the material composing the bed rests on the top of a perforated surface which lets the fluid pass rapidly through the false floor and away, carrying any suspended matters with it, and leaving the empty spaces to assist aeration. Before sewage is delivered on to any kind of bacteria bed it is essential that as much solid matter as possible should be arrested by sedimentation to prevent the beds clogging and the interstices being choked with matter which cannot possibly be acted upon by bacteria. Much of the data as to the purification or disposal of sewage by filtration shows that the failure, or inefficiency, of the beds to continue their successful working for long periods has been due entirely to non-compliance with this essential condition.

Contact Beds. Another system which depends on the action of bacteria for the treatment of sewage is that called the *contact bed*, with which the name of Mr. Dibdin will always be associated. The principle on which they are worked is to pass sewage into a chamber containing suitable filtering material until it is filled, then leaving the sewage at rest for a time in the filled chamber, after which the filtrate is run off, and the empty tank is left at rest for a time, during which the aeration of the interstices is effected.

The annual report of the Manchester Corporation Rivers Department for the year ending March 29th, 1905, contains a great deal of information regarding the results of both the experimental and permanent works which have been carried out to deal with the sewage of Manchester and adjacent places.

The following useful information is given with reference to the treatment of the sewage in open septic tanks and bacteria beds.

The total flow through the septic tanks during the year amounted to 6,189,995,000 gallons, or an average of about 17,000,000 gallons per day.

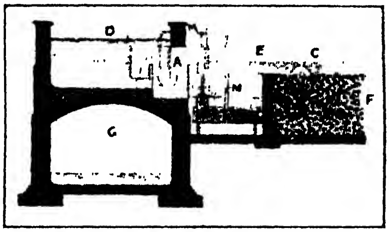
The total amount of sludge removed from the septic tanks—namely, 72,310 tons—is equal to 11 tons 14 cwt. per million gallons. The corresponding figure for the previous year was 6 tons, the average for the two years thus being 8 tons 27 cwt. of sludge per million gallons, as compared with 18 tons 2 cwt., the average amount of sludge per million gallons obtained by chemical treatment from 1899 to 1901. Or, taking the total production of sludge, including that deposited in the settlement tanks, the average for the last two years is 2,860 tons per week, as against 3,902 for the years 1899 to 1901.

At the date of the report $42\frac{1}{2}$ acres of beds were in operation, so that with the completion of the remaining seven beds the whole area of primary beds will be available. The quantities dealt with are obtained by the use of the following sliding scale of capacities.

Number of fillings.	Capacity of bed.
0 to 200	180,000
200 to 500	160,000
500 to 750	150,000
750 to 1,000	140,000
1,000 to 1,200	130,000
1,200 to 1,500	110,000
1,500 +	100,000

Aeration of Contact Beds. After careful observation at the Manchester sewage outfall Dr. Fowler, who had charge of the works, came to the conclusion that the period of resting the contact bed when empty is more important than the time when the bed is left at rest full, and that generally it is not desirable for the latter time to exceed one hour. This is a useful experience to record. The aeration of the contact beds, when empty, is

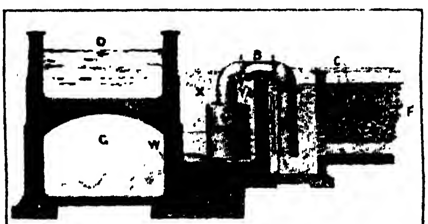
due to the organisms contained in them absorbing oxygen and producing carbon dioxide. The natural interchange of gases which takes place causes the aeration of the beds. It is generally found that the interstices between the material composing the beds is about one-third of the total capacity of the bed, so that if the basis of three fillings a day is adopted the volume that the beds are capable of dealing with would be represented by the actual capacity of the beds.



40. FILLING A CONTACT BED

The depth of the beds is governed to a great extent by the levels at which the sewage is delivered and discharged, dependent on local conditions. Shallow beds drain more rapidly and are, therefore, to be preferred. If the available area of the outfall plot is limited, deep beds would have to be used, whereas shallow ones could be employed on larger areas.

A Second Contact Bed. By using a second contact bed a higher degree of purity can be attained than with only one. The second one can be worked at twice the rate of the first, thus involving only one secondary bed for two primary ones. The filtering mediums used in every kind of sewage filter must be free from any fine matter which can tend to fill up the interstices. It should also be incapable of disintegration by exposure to the passage of the sewage through the filter. The material to be employed depends, to a large extent, on the locality, and may be hard coke breeze, coal, broken hard bricks, sifted and selected debris from stone or slate quarries, slag and clinker. As has been explained, it is necessary when adopting this system of sewage purification that the liquid must remain in contact with the filtering medium before being run off. In order that this may be accomplished automatically, various devices have been designed, among which may be mentioned that of Adams-Hydraulics, Limited [40 and 41].



41. EMPTYING A CONTACT BED

The illustrations show the air-lock feed and automatic methods of discharging a bed after it has been standing full for a time. Fig. 40 shows the method of filling; the sewage enters the bed, through a syphonic feed, A, and is conveyed by means of a distributing trough, C, to the bed. The liquid is admitted to M through a small syphon (not shown). As it rises, it compresses the air in the domes K and N; the compressed air in K forms an air lock in A, which automatically shuts off the supply, while the compressed air in N is connected to the feed of another bed, in order to break the air lock in that feed and allow filling to begin. The method of emptying a bed is shown in 41. The liquid in the bed has access through perforations to a chamber in which is a syphon, Z, and a bent pipe fitted with a cock, Y. This cock is adjusted to admit into the chamber X enough liquid to fill it in any required time; the syphon then comes into operation and empties the bed.

Percolation Beds. As the function of anaerobic bacteria are known to be best discharged without air, and those of aerobic bacteria depend on plenty of air, it is difficult to appreciate how a contact bed can be right, as the emptying, filling, and resting process appears incompatible with either requirement. The aim should be to let the sewage percolate, or trickle, over the largest surface in the presence of the maximum amount of air, by which the best oxidisation must be effected. The material used for filling these beds must comply with the conditions laid down as regards absence of substances that may choke or clog the bed.

As already stated the sewage, before passing to a percolating bed must have passed through some form of sedimentation chamber in which the solid inorganic matters will have been deposited, and a certain amount of liquefaction of organic solids will have taken place, depending upon the size of the chamber and the rate of flow through it.

The satisfactory results that have been obtained at a great many places by passing sewage over the surfaces of the material composing a percolating bed have established this system as one that affords a solution, although not necessarily the only one, of the problem of the disposal of sewage at outfalls, where irrigation is not possible, and where the cost of chemical precipitation is to be avoided.

Continued

THE MANUFACTURE OF STEEL

Constitution of Steel. Tempering and Temper. Alloys of Steel. Various Methods of Producing Steel. Armour Plate

By A. H. HIORNS

STEEL is an alloy of iron and carbon, and its peculiar characteristics have been known from very early times. Yet the phenomena of hardening, tempering, and annealing have been clearly indicated only in the last decade, owing chiefly to the revelations of the microscope and the pyrometer, combined with chemical analysis.

In the solid state the maximum amount of carbon that pure iron can retain is 4·23 per cent. The presence of foreign bodies raises or lowers this quantity according to their nature and amount. Three chief forms of carbon in iron are generally recognised—namely, *graphite carbon*, *cement carbon*, and *hardening carbon*. Graphite is comparatively rare in steels. Cement carbon is really carbide of iron. It exists in unhardened or annealed steels, and has the chemical formula Fe_3C. Hardening carbon is found in hardened steels, and the hardness, brittleness, and tenacity of the steels increase with the increase of hardening carbon up to the limit of about 1·3 per cent. of carbon as regards tenacity, and probably to 4·3 as regards hardness. In tempered steel some of the hardening carbon has been released, forming cement carbon, hence the diminution of hardness and brittlensss.

Hardening of Steel. When steels containing over 0·25 per cent. of carbon are suddenly quenched from a red heat they become *hardened*. The degree of hardness increases with the percentage of carbon, with the rise of temperature, and with the rapidity of cooling. The real cause of hardening is unknown, but according to the theory of Osmond, which is largely accepted, it is due to a hard allotropic modification of iron which exists at certain ranges of temperature, depending on the amount of carbon present. Whether the hardness be due to this cause or not is a matter of pure theory, but it is a fact that in mild steel and malleable iron there are three well-marked critical points. They are distinguished as described in this table:

	Beginning.	Maximum between.	Conclusion.
Ar. 3	845 C.	825° to 819° C.	800° C.
Ar. 2	755° C.	736° „ 725° C.	710° C.
Ar. 1	680° C.	662° „ 655° C.	645° C.

In medium steel the points Ar. 2 and Ar. 3 are combined into a single point, reaching a maximum at about 720° C., and the point Ar. 1 has a maxium at about 660° C. In high carbon steel there is only one break in the cooling of long duration, at 674° C. Ar. 1 is absent in pure iron, therefore it is a function of the carbon in steels corresponding to the change from hardening to cement carbon in cooling the steel. Ar. 2 is identical with the disappearance of magnetism. Osmond recognises the existence of three allotropic forms of iron. Above Ar. 3 the iron is in the *gamma* form. Between Ar. 2 and Ar. 3 the iron is in the *beta* form, and below Ar. 2 the iron is in the *alpha* form. According to this theory, beta and gamma iron are hard and alpha iron is soft. Hence, by suddenly quenching steel from above the point Ar. 2, the change is prevented and the steel remains hard.

By the carbon theory, hardening is due to the condition of the carbon above certain critical temperatures termed *hardening carbon*, which is retained in that state by sudden cooling and decomposed on slow cooling. It is probable that the phenomenon of hardening is due to both the allotropic form of iron and the hardening carbon.

Tempering. On cautiously reheating hardened steel to a certain point, the tension is released, some carbide is set free, the steel loses its brittleness and becomes softer and more elastic. This operation is termed *tempering*. The temperature for tempering varies with different articles, and is judged by the colour of the film of oxide on the brightened surface. The following table, from the writer's "Steel and Iron," shows the tempers for various articles:

Percentage of carbon.	Temperature.	Colour.	Article.
1·5	220° C.	Faint yellow ..	Surgical knives.
	230° C.	Straw yellow ..	Razors, knives, hammers, taps, and dies.
	255° C.	Brownish yellow	Scissors, hard chisels, shears.
1·3	265° C.	Purplish brown	Axes, planes.
	277° C.	Purple	Table knives.
	280° C.	Violet	Cold chisels for brass, punches, etc.
0·9	288° C.	Light blue ..	Swords, coiled springs.
	293° C.	Dark blue ..	Fine saws, augers.
0·8	316° C.	Blackish blue ..	Hand saws, cold chisels for copper and wrought iron.
0·6	400° C.	Black	Spiral springs.

Steels expand on hardening, varying with the amount of carbon present, and the higher the carbon the lower should be the temperature to which the steel is raised. Small tools are plunged into water or oil. Bulky articles are placed in water and deluged with a stream of water. Files must have their teeth protected with a fusible paste before heating. Saws are heated in an air or gas furnace and quenched in whale oil. They are tempered by burning off the oil. Hammer-heads and steel-faced articles have the other parts kept cool with a wet rag while the faces are heated.

Effect of Work. Ingot metal is improved by fagoting and welding. Up to a certain limit, and avoiding working at a blue heat, the tensile strength and elongation are increased by cold rolling and hammering. The elastic limit is raised and the area is reduced. If the sectional area of a piece of steel be reduced to 30 per cent. or 40 per cent. by hot working, each per cent. of diminution of area increases the tensile strength and elastic limit by about 0·2 per cent., and the elongation and contraction of area by about 1·5 per cent. Hot working expels slag, welds detached particles, closes pipes and blowholes, and prevents undue crystallisation. Hammering is generally superior to rolling in yielding the results mentioned.

COMPOSITION OF VARIOUS STEELS

	Carbon.	Silicon.	Manganese.	Phosphorus.	Sulphur.
Shafts and boiler plate	0·16	0·03	0·30	0·04	0·03
Wire	0·05 to 0·10	0·04	0·50	0·04	0·05
Gun barrels	0·22	0·20	0·03	0·02	..
Structural steel ..	0·25	0·06	0·50	0·03	0·01
Guns	0·30	0·04	0·50	0·04	0·10
Axles and rails.. ..	0·40	0·01	1·00	0·10	0·04
Rolls and springs ..	0·50	0·20	0·40	0·04	0·05
Cutlery and American rails	0·50 to 0·60	0·10	0·60 to 1·00	0·05	0·06
Projectiles	0·60	0·25	0·60	---	—
Chipping chisels and tools	0·75 to 0·85	0·02	0·05	0·05	0·06
Dies	0·80	0·02	—	0·02	0·01
Saws	0·90	0·30	0·30	0·03	..
Drills and turning tools	1·00	—	0·30	..	—
Saws, files, and 14-in. files	1·30	0·10	0·20	0·05	0·03
Razors and lancets ..	1·50	0·10	0·20	0·05	0·03

SILICON. The amount of silicon in mild steel is generally very small, but amounts up to 0·05 per cent. do not impair strength and welding properties. In high carbon steel silicon is more hurtful.

SULPHUR. The influence of sulphur with less than 0·05 per cent. on the tenacity and ductility of steel is very slight, but beyond this amount it causes red-shortness. But manganese, which is usually present, neutralises the influence of sulphur to a great extent. Sulphur has a tendency to cause development of fine cracks.

PHOSPHOROUS. Small quantities under 0·1 per cent. do not effect the hot-rolling properties or the tensile strength, but phosphorus is very dangerous when the steel is subjected to vibration or sudden shock. In structural steel the phosphorus should not exceed 0·06 per cent., and in high carbon steel it should not be more than 1·01 per cent.

MANGANESE. This is an essential constituent of structural steel, but the less it contains above that required to produce soundness and freedom from red-shortness, due to sulphur, the better, and for these purposes 0·50 should be sufficient. Manganese tends to increase tenacity and reduce ductility. In high carbon steels the effect of manganese is more marked, and tends to produce fractures on quenching for hardening.

ARSENIC. In quantities of less than 0·15 per cent., arsenic has no effect on the mechanical properties of steel. Above this amount cold-shortness is noticeable, and prevents good welding.

COPPER. In small quantities, copper has no influence on the physical properties of steel.

Segregation. In considering the effect of impurities on steel, the temperatures of casting, reheating, and work put upon the metal must be considered. Moreover, the effect of an element on steel is modified by the simultaneous presence of other constituents. While it is easy to determine the influence of a single element on steel, it is very difficult when four or five elements are present. Another point of difficulty is the tendency of certain constituents to segregate, especially when the steel is slowly cooled. Howe divides bodies which tend to segregate into three groups: (*a*) compounds which differ from the rest in fusibility; (*b*) compounds which have a strong affinity for each other; (*c*) compounds which differ greatly in density from the rest of the mass. Carbon and phosphorus have a great affinity for manganese. Carbides, phosphides, and sulphides of iron are more fusible and have lower densities than alloys of iron and manganese. It is generally found that segregation of one impurity induces segregation of the rest. Sulphur, phosphorus, and their compounds are generally most unequally distributed. Carbon also very readily segregates. Chrome and tungsten steels are very liable to segregation, while nickel steels are remarkable for their uniformity.

Steel Alloys or Special Steels. The varieties of steel already considered are termed *carbon steels*, but special steels contain other metals alloyed with iron, with or without much carbon. The metals which chiefly influence the properties of steel and are used for industrial purposes are: *manganese, nickel, chromium, tungsten, aluminium, vanadium*, and *molybdenum*.

Manganese is generally present in commercial steels from 0·3 to 1 per cent. Manganese steel contains 12 to 14 per cent. of manganese and about 1 per cent. of carbon. It has a high tensile strength and elongation, is self hardening, and is used for various tools. It is non-magnetic, and offers great resistance to electricity.

Nickel forms with iron and carbon most valuable alloys, termed *nickel steels*. Steel with 3 per cent. of nickel and 0·2 per cent. of carbon has a tensile strength 10 per cent. greater than any ordinary carbon steel of the same quality, with an increase of 25 per cent. of elastic limit. The ratio of elastic limit to tensile strength increases up to 20 per cent. of nickel and then falls away rapidly. The hardening effect ceases with 10 per cent. of nickel. Above 1 per cent. the difficulty of welding increases. Steel with 25 per cent. of nickel is scarcely magnetic, but becomes so when cooled to −40° C., and does not regain its non-magnetic properties until heated to 600° C.

Steel containing 2 per cent. of nickel, 1 per cent. of chromium, and 0·4 per cent. of carbon is used for armour-piercing shells. The nickel toughens, while the chromium and carbon harden the steel. Nickel steel offers greater resistance to corrosion than wrought iron or mild steel.

Chromium does not impart hardness to steel, but in small quantities it raises the tensile strength and in large quantities the brittleness. Chromium does not of itself harden iron. Steel with 1 per cent. of carbon and 2 to 3 per cent. of chromium is used for projectiles, and with 1 to 2 per cent. of chromium for special files. Chrome steel is used for railway tyres and springs.

Tungsten is added to steel for self-hardening cutting tools and for magnets. Excellent tools can be made from steel with 1 per cent. of carbon and 7 per cent. of tungsten. A small percentage of tungsten in ordinary tool steel improves the wearing properties. Mushet steel contains 1·5 per cent. to 2 per cent. of carbon and 5 per cent. to 8 per cent. of tungsten. Tungsten is one of the constituents of high-speed tool steels.

Aluminium is not used as a definite alloy of iron in steel, but plays an important rôle in increasing the fluidity of cast steel, in stopping the evolution of gas, and in assisting to prevent blowholes. It also has a great affinity for oxygen, and reduces the iron oxide present. Aluminium, like silicon, causes the carbon to separate as graphite. It therefore combines the advantages of silicon to some extent with that of manganese.

Vanadium exerts a more powerful influence on steel than any metal yet discovered. Its general effect is to increase the tensile strength and elastic limit, and to reduce the elongation somewhat. One per cent. to 2 per cent. raises the strength of mild steel 50 per cent. It probably forms a double carbide of iron and vanadium, which seems to be uniformly distributed, preventing segregation, and thus removing a cause of brittleness due to vibration. As vanadium acts in the same way as carbon, the amount of the latter must be carefully controlled.

Molybdenum readily unites with iron, and acts like tungsten. Molybdenum iron alloys are fairly fusible, and molybdenum steel must not be heated to a high temperature. Rapid quenching in water hardens it like ordinary steel.

High-speed Tool Steels. Alloys of chromium-tungsten or chromium-molybdenum, or both, have been recently introduced into steel with marvellous results. The resistance of these special steels increases with a rise in temperature. The percentage composition varies with the work to be done from about 0·75 per cent. of chromium and 4 per cent. of tungsten to 3 per cent. of chromium, 8 per cent. of tungsten, and 4 per cent. of molybdenum, the last-named being used for working hard steel or chilled iron. The percentage of carbon is under 1 per cent. The steel is first heated to 1,000° C., then cooled to below 840° in a lead bath, and kept stationary at 400° to 500° C. for a few minutes. A fusible slag is used to protect the metal from oxidation while heating. This method of treating self-hardening steel was discovered by Messrs. Taylor and White. They found that heating the alloy far above the usual temperature and cooling regularly gave great increase in hardness. Different makes of these special steels are on the market, and they are hardened by heating to about 1,200° C. and cooling with an air blast.

Direct Method of Steel Production. This is the same as for iron in the Catalan and similar forges. The direct method yields iron nearly free from carbon, or some carbon may be left in the iron forming steel. The slag, being highly basic, takes up much of the phosphorus, but there is a greater tendency of the iron to absorb sulphur. With good ores and charcoal as fuel, phosphorus and sulphur are practically absent from the steel. If the direct process is conducted in a retort furnace, it is scarcely possible to get a sufficiently high temperature to raise the metal to a balling heat, hence only a sponge is produced. In furnaces capable of a welding temperature, the balls are not homogeneous, the carbon varying throughout. Balling is advantageous where the balls can be taken to an open hearth furnace for completion.

Crucible Process. This consists of melting iron in crucibles with or without carburising additions, allowing the molten steel to stand for killing, and then pouring into moulds.

Huntsman's process is a method of melting blister steel in crucibles with a flux, such as potassium, ferrocyanide, nitre, fluorspar, sand, or oxide of manganese.

Heath's process consists of adding manganese to blister steel, but is now modified by using oxide of manganese and carbon.

Uchatius' method, or pig iron and ore method, as practised in Sweden, consists in melting granulated cast iron with iron ore, whereby the carbon is largely oxidised by the oxygen of the ore.

Carburising fusion method. In this case malleable iron is melted with the necessary amount of carbon to form steel.

Pig and scrap method. If wrought iron nearly free from carbon be melted with a certain proportion of pig iron, a crude steel is produced.

The crucible process is more costly than the Bessemer process in cost of materials, labour, fuel, and refractory materials, but the steel is generally of better quality. Its costliness limits its use to cutting tools, springs, fire-arms, etc.

The crucible process differs from the open hearth in treating small charges, in using purer materials, in excluding the fire gases, and in being less under control as to temperature, time, etc. There is less liability to the absorption of sulphur, nitrogen, hydrogen, and other gases.

Crucibles. Two kinds of crucible are used—*graphite* and *clay*. Graphite crucibles last longer, endure harder usage, hold heavier charges, and cause less loss of iron than the clay variety; but they give up more carbon and silicon.

Clay crucibles are made of a mixture of different fireclays, burnt clay, and a little coke-dust. The raw clay forms about two-thirds of the mixture. Hand-made crucibles have a hole left in the bottom, and a little sand is added, which fuses the stand to the crucible when strongly heated. The charge for a clay pot is 56 lb., and for a graphite pot 60 to 90 lb.

Crucible Steel. When the charge has been introduced, the pot is covered with a lid, for if a bit of coke should enter the steel becomes hot-short. When the metal is melted the pot is kept in the fire sufficiently long to remove

gases and prevent blow-holes. This is termed *killing*. The effect is probably due to the reduction of silicon from the clay and its absorption by the steel.

If the killing be too long, too much silicon enters the steel, and the metal becomes hard and brittle. The hotter the furnace the shorter the time required for killing. The same result is obtained by adding aluminium. If the steel be insufficiently killed it will teem fiery, and the ingot of steel will be unsound. A little ferro-manganese, or spiegeleisen, is generally added to promote soundness. In the ingot of steel, after cooling, the top or piped part is broken off, and the metal graded, according to the appearance of the fracture—that is, according to its carbon content. As an example of the best crucible steels, the following analyses may be taken:

Carbon.	Silicon.	Manganese.	Phosphorus	Sulphur.
1·31	0·05	0·14	0·010	0·003
1·44	0·10	0·14	0·015	—
0·96	0·10	0·13	0·012	—

It is difficult to make crucible steel of the above composition free from blow-holes and oxides, so that manganese is generally added to the charge, if that element be not present in the iron, with the result that the steel is sounder, but higher in manganese and silicon. Cast steel contains 1·6 to 0·78 per cent. of carbon, 0·5 to 0·23 per cent. of manganese, 0·25 to 0·04 per cent of silicon, and about 0·02 per cent. of phosphorus.

The proportion of carbon in steel is termed its *temper*, which has nothing to do with tempering. Also high carbon steels are termed *hard* steels, which has nothing to do with the process of hardening.

Tempers for Various Purposes. Seebohn gives the following list of useful tempers for steels:

Razor temper (1·5 per cent of carbon), easily burnt by overheating.

Saw-file temper (1·35 per cent. carbon), should not be heated above a cherry-red heat.

Tool temper (1·25 per cent. carbon), useful for turning tools, drills, and planing-machine tools, cutters, etc. Can be welded.

Spindle temper (1·12 per cent. carbon), useful for mill-picks, cutters, large taps, dies, etc.

Chisel temper (1 per cent. carbon), combines great toughness with the power of being hardened at a low red heat, and can be welded and adapted for tools where the unhardened part is required to bear a blow, as in cold chisels, etc.

Set temper (0·9 per cent. carbon). For cold sets to withstand heavy blows.

Die temper (0·75 per cent. carbon). The tools must be hard, and yet withstand hammering, concussion, and great pressure.

The Furnace. The ordinary furnace, or *teeming hole*, is a rectangular cavity, 18 in. to 24 in. square, and 3 ft. to 4 ft. deep. It is lined with refractory material. A number of these furnaces are arranged along one side, or two rows may be built back to back. The teeming-holes are on a level with the shop floor, and covered with iron plates while the metal is being melted. The melting chambers are separated from each other only by a brick wall, except for the refractory lining, which in Sheffield is ganister. This is rammed round an elliptical wooden core, or template, 26 in. long by 19 in. wide.

When this is withdrawn the space thus lined is an elliptical cavity, capable of holding two pots. The ends of the firebars rest on bearers, built into the brick wall below the level of the roof of the vault beneath. This enables the bars to be accessible for withdrawal in case of a pot breaking. Each fire has its own ash-pit, as well as its own flue. These flues are carried up in groups of five or six into a stack about 40 ft. high, and each one is continued down to the ash-pit below. By inserting a brick through an opening into the flue, the draught of each fire can be regulated. Around the sides of an old-fashioned melting-house are shelves for drying the crucibles previous to annealing. They are now generally dried in special chambers.

Special Types of Furnaces. A gas-fired crucible furnace was introduced by Siemens. It is of the ordinary regenerative type, with two pairs of regenerators for heating the gas and air respectively. The saving of fuel, as compared with the old furnace, is as 4 to 5—that is, the gas furnace will burn four tons of coal, as compared with five tons of coke in the air furnace; but it must also be remembered that the gas furnace burns common slack, so that the difference in cost of fuel is considerable. The regenerative furnace may be constructed to hold any number of pots, a 24-pot furnace being a convenient size. The upper portions are built of silica bricks, and much expense may be saved by patching up the blocks between the ports, when defective, with ganister instead of waiting to put new bricks in. A 24-pot furnace requires a space of about 20 square feet, and is placed entirely below the ground level. For ordinary qualities of steel 13 heats per week may be obtained.

The Nobel liquid fuel furnace is an arrangement for heating a number of crucibles with refined petroleum. It is cheaper to build than a gas-fired furnace, and uses less fuel than the solid-fired furnace, but the cost of fuel is greater when burning petroleum than when burning gas. Each furnace contains three holes, two of which contain two crucibles each, and the third space is left empty. These three holes are arranged in a row, so that the flame passes through them in succession before going into the chimney.

Cementation Furnace. Cementation is a process of carburising wrought iron by heating it in stone or brick chests in contact with charcoal for a prolonged period. The furnace is an oblong chamber with a semi-cylindrical roof containing two converting chests, heated by a fireplace below and between them. The flame is distributed by a number of flues around the chests, and finally passes into a chimney. The chests vary in size, from 8 to 15 ft. long, and are about 3 ft. wide and high. The introduction and withdrawal of the charge is through manholes in the side walls. In each chest is a square hole through which a trial bar projects.

The Cementation Process. To charge the chest a layer of coarse charcoal is placed on the bottom, then a layer of iron bars placed side by side. These alternate layers of iron and charcoal are continued till the chest is nearly full. A thick layer of charcoal is placed on the top, and on this is put a layer of siliceous material, termed *wheel-swarf*, which frits with the heat and forms an impervious coating. The bars of iron used are about 3 in. wide and ¾ in. thick.

In about 24 hours the chests are raised to a red heat, and in about three or four days attain the requisite temperature. This is then maintained for 7 to 11 days, according to the grade of steel required, the hardest requiring the longest, and spring steel the shortest time. Conversion begins at 900° C., and goes on more actively at higher temperatures. By cementation the physical properties of the iron are changed, the colour being reddish-white, and the structure highly crystalline. The surface is studded with blisters, due to the attempt of the gases to escape, hence the name *blister steel.*

The manner in which the carbon passes through the iron is probably in the form of gaseous compounds, which are decomposed, giving up their carbon to the iron, or it may be that the gaseous compounds are decomposed at the surface, and the combined carbon transmitted layer by layer.

Cemented Bars. Cemented bars are classified in six grades. The lower numbers contain a central core of unaltered iron, and the highest are converted all through. A special kind called *glazed bar* has been doubly converted and contains the highest percentage of carbon.

Blister steel is treated in two different ways—*fagoting* and *welding*, or *melting* in crucibles for cast steel. The mild variety is used for springs, and the higher carbon steels after fagoting and welding are termed *shear steel.* By cutting up, fagoting and welding a second time, double shear steel is produced. The texture of blister steel is modified according as it has been rolled or hammered. Hammered steel has the finer grain and greater power of resistance.

Case Hardening. This is the formation of a surface layer of steel on iron or mild steel by a rapid process of cementation. The articles are embedded in carbonised bones, leather, or horn, and packed in an iron box. The box is then heated at the ordinary cementing temperature until a sufficient depth of steel is obtained. This may be one-eighth of an inch in four to five hours. If the temperature be raised too high, the iron itself becomes hard and brittle. The work when removed from the fire is hardened by plunging into water. If only certain parts are required hard, the cemented iron is allowed to cool slowly, the surface of the parts to be soft are turned off in a lathe, and the article is hardened.

Small articles are rapidly case-hardened by cleaning, making red hot, and rubbing in yellow prussiate of potash, K_4FeCy_6. As soon as the powder has volatilised, the article is plunged into water.

Armour Plate. There are two chief varieties of armour plate now manufactured, each being made by a different process. The object sought is to produce a plate which shall not crack when struck with a shell, and be sufficiently hard to resist penetration. The older method was to have a plate of iron united to a face of hard steel, thus combining toughness with resistance. When the properties of nickel steel were discovered, it was found very suitable for armour plates. This introduced plates made entirely of steel. Another great improvement was introduced by Harvey, who took mild steel as a base, and carburised the surface by a cementation process, the carburised face being afterwards hardened by sudden chilling from red heat.

Open-hearth mild steel, alloyed with varying percentages of nickel, vanadium, or chromium is cast into large ingot moulds, then hammered and rolled into the required thickness, and passed to the carburising shop to undergo the Harveyising process. Such a plate of steel containing 1·1 per cent. to 0·3 per cent. of carbon is placed on a bed of finely powdered clay or sand, deposited on the bottom of a firebrick compartment erected within the heating chamber of a suitable furnace. The compartment is then filled with granular carbonaceous material and well rammed down on the plate. This is covered with sand, and finally with a layer of heavy firebricks, as a heavy pressure on the carbon facilitates its union with the iron. The furnace is raised to a high temperature for about a fortnight, when the steel, to a depth of an inch or more, has taken up an additional 1 per cent. of carbon. The plate, when sufficiently carburised, is freed from its covering, and all bending and machining done, holes drilled, etc.

Hardening Armour Plate. The hardening process consists of heating the plate, placed on an iron grid, to a cherry red heat, and by spraying jets of water on the top and bottom surfaces at a pressure of 10 lb. per square inch. Any final adjustment after hardening can be done only by grinding.

Krupp, of Essen, carburises by means of gaseous hydrocarbons and then hardens. Two plates are placed on the hearth, one above the other, with a space between, and with their faces inwards so that the carburising gases may pass between them.

Beardsmore's process of making compound armour plate is to produce ingots composed of layers of hard and soft steel perfectly united. A layer of steel is run into a horizontal mould, the bottom of which is kept cool, which causes the bottom layer of steel to set quickly, and while the upper layer is still liquid a charge of milder steel is poured in, and unites with it, and so on with a third layer of still softer metal. The ingots are pressed and rolled into plates. By this means a much greater depth of hard steel can be produced than is possible by a cementation process such as Harvey's or Krupp's.

Continued

FIRE-RESISTING CONSTRUCTION

Group 4
BUILDING
33

Continued from page 4648

Regulations of Building Acts and By-laws. Special Materials. The Construction of Walls, Floors, Partitions, and Roofs. The Protection of Openings

By Professor R. ELSEY SMITH

NO building material will permanently resist the action of fire; but it is practicable in many cases to construct buildings of such a character that in the event of a fire breaking out in one compartment it may be confined to that compartment.

Much of the legislation devoted to building is designed to minimise the danger of fire spreading from one building to another, or at least to prolong the period during which it may be possible to prevent such spreading. It is, however, a very difficult matter to render buildings absolutely fire-resisting. The necessity for openings for light and access, even if the fittings and finishings of such openings are themselves incombustible, provide ready means of admitting currents of air to fan the flames if once an outbreak should occur within the building. In buildings of ordinary type it is the work of the carpenter and joiner that provides most fuel for the flames if a fire should occur. Even in a building of the most complete fire-resisting construction, if the contents are inflammable, and fire gets a good hold of them, they may burn so fiercely as to endanger the structure, or portions of it at least.

The Element of Cost. An important factor in determining to what extent fire-resisting materials and construction shall be used in any building is that of cost. A building that is carried out so as to be as far as possible fire-resisting, will be more costly to construct than one of the same size in which such precautions are not taken; but where the contents are of great value, the difference in the rates of insurance usually made by the insurance companies between the two classes of buildings may be sufficient to render the more costly form of construction really economical in the long run.

The Law's Protection Mainly Given to Life. The law, so far as it enforces fireproof construction does so with a view to the preservation of life rather than of property; even the builder of a detached house in a town or urban district, and in many rural districts, is restricted to the use of non-combustible materials for the main walls and roof-coverings.

As soon as a building ceases to be a purely domestic building, but is used partially for trade or manufacture, attention is directed also to the internal structure, and regulations are frequently made as to the nature of the materials to be used in the construction and support of corridors, passages, and staircases, with a view to safeguarding the escape of those occupying the upper part of such premises in the event of fire breaking out below.

Factories and Public Buildings. In factories where considerable numbers are employed, and in buildings divided up into separate tenements, and in all buildings intended for the use of the general public, more stringent rules are framed to ensure as far as possible the safety of those making use of them, and in particular to ensure some safe means of escape from the building in case of fire.

Standards of Protection. The British Fire Prevention Committee have proposed three standards implying different degrees of protection, and these have been confirmed by the International Fire Prevention Congress, London, 1903:

1. *Temporary protection*, which implies resistance to the action of fire for at least three-quarters of an hour.
2. *Partial protection*, which implies resistance to a fierce fire for at least one hour and a half.
3. *Full protection*, which implies resistance to a fierce fire for at least two hours and a half.

Each of these classes is subdivided into two others, A and B respectively, and definite standards are published of the tests that any material must fulfil for classification in each division and class, depending on the purpose for which it is to be employed.

Structural Iron and Steel in Fire-resisting Buildings. It is the introduction of iron and steel which has rendered possible the construction of modern fire-resisting buildings. These materials enable very heavy loads to be carried on supports of but small area, which supports may be adequately protected from the action of fire without greatly adding to the area occupied by them.

The protection of the iron and steel used structurally, however, is an essential element in successful fire-resisting construction; iron, it is true, is not combustible, but it is not fire resisting, for when it becomes heated by exposure to the direct action of fire its strength and stiffness become most materially reduced; at the same time expansion takes place to a very appreciable extent, and unless provision has been made for this, beams and columns may become seriously distorted, and contribute to the collapse and destruction of the building in which they are used. Iron and steel, therefore, while essential in modern fire-resisting construction, are materials that cannot be safely exposed to the direct action of the fire.

The London Building Act and Fire-resisting Materials. The materials recognised in the London Building Acts (Amendment Act), 1905 [5 Edw. 7], as fire-resisting for general

purposes are given below. This Act is not in force beyond the limits of the metropolis, but as it represents the recent views of the authority controlling building operations throughout the greatest city in the world, it serves as a useful guide:

(*a*) Brickwork constructed of good bricks, well burnt, sound and hard, properly bonded and solidly put together (*a*) with good mortar compounded of good lime and sharp, clean sand, hard, clean broken brick, broken flint, grit or slag; or (*b*) with good cement; or (*c*) with cement mixed with sharp, clean sand, hard, clean broken brick, broken flint, grit, or slag.

(*b*) Granite and other stone suitable for building purposes by reason of its solidity and durability.

(*c*) Iron, steel, and, copper.

(*d*) Slate tiles, brick and terra-cotta, when used for coverings or corbels.

(*e*) Flagstones when used for floors over arches, but such flagstones not to be exposed on the under side and not supported at the ends only.

(*f*) Concrete composed of broken brick, tile, stone clippings, ballast, pumice or coke breeze, and lime, cement or calcined gypsum.

(*g*) Any combination of concrete and steel or iron.

Material for Special Purposes. For special purposes other materials are sanctioned; the provisions affecting them, detailed in the schedule, may be summarised as follows:

Timber. Oak, teak, jarrah, karri, or other hard timber, not less than $1\frac{3}{4}$ in. finished thickness, may be used for doors [2] and shutters and their frames, the latter being bedded solid to the walls or partitions; also for treads, risers, strings, and bearers of staircases [1] and landings—the ceilings or soffits (if any) being of plaster or cement—and for verandahs, balustrades, outside landings, the treads, strings, and risers of outside stairs, outside steps, porticos, and porches.

The same materials may be used for beams or posts, or in combination with iron, the timber and iron (if any) being protected by plastering or other incombustible or non-conducting external coating not less than 2 in. in thickness; or, in the case of timber, not less than 1 in. in thickness on iron lathing.

For floors and roofs, brick, tile, terra-cotta, or cement composed as described above (*f*), not less than 5 in. thick, in combination with iron or steel, is permitted. For the floors and roofs of projecting shops, pugging of concrete, as described above (*f*), not less than 5 in. thick between wood joists, is allowed; this may be carried by fillets 1 in. square spiked to the joists and placed so as to be in the centre of the thickness of the concrete; or concrete blocks, not less than 5 in. thick, may be used, carried on fire-resisting bearers secured to the sides of the joists [5].

Internal Partitions. For internal partitions inclosing staircases and passages, terra-cotta, brickwork, concrete, or other incombustible material, not less than 3 in. thick, is permitted. For glazing windows, doors, and borrowed lights, lantern or skylights, glass must be not less than $\frac{1}{4}$ in. in thickness, in direct combination with metal the melting point of which is not lower than 1,800° F. in squares not exceeding 16 sq. in., or in panels not exceeding 2 ft. across either way. The panels must be secured with fire-resisting materials in fire-resisting frames of hard wood not less than $1\frac{3}{4}$ in. finished thickness, or of iron. The Council reserve the right to approve from time to time other materials.

Many of the materials referred to have been already described, or will be dealt with at greater length in the subsequent parts; but some special reference to some, at least, of them is desirable before a description of the methods of fireproof construction is entered upon.

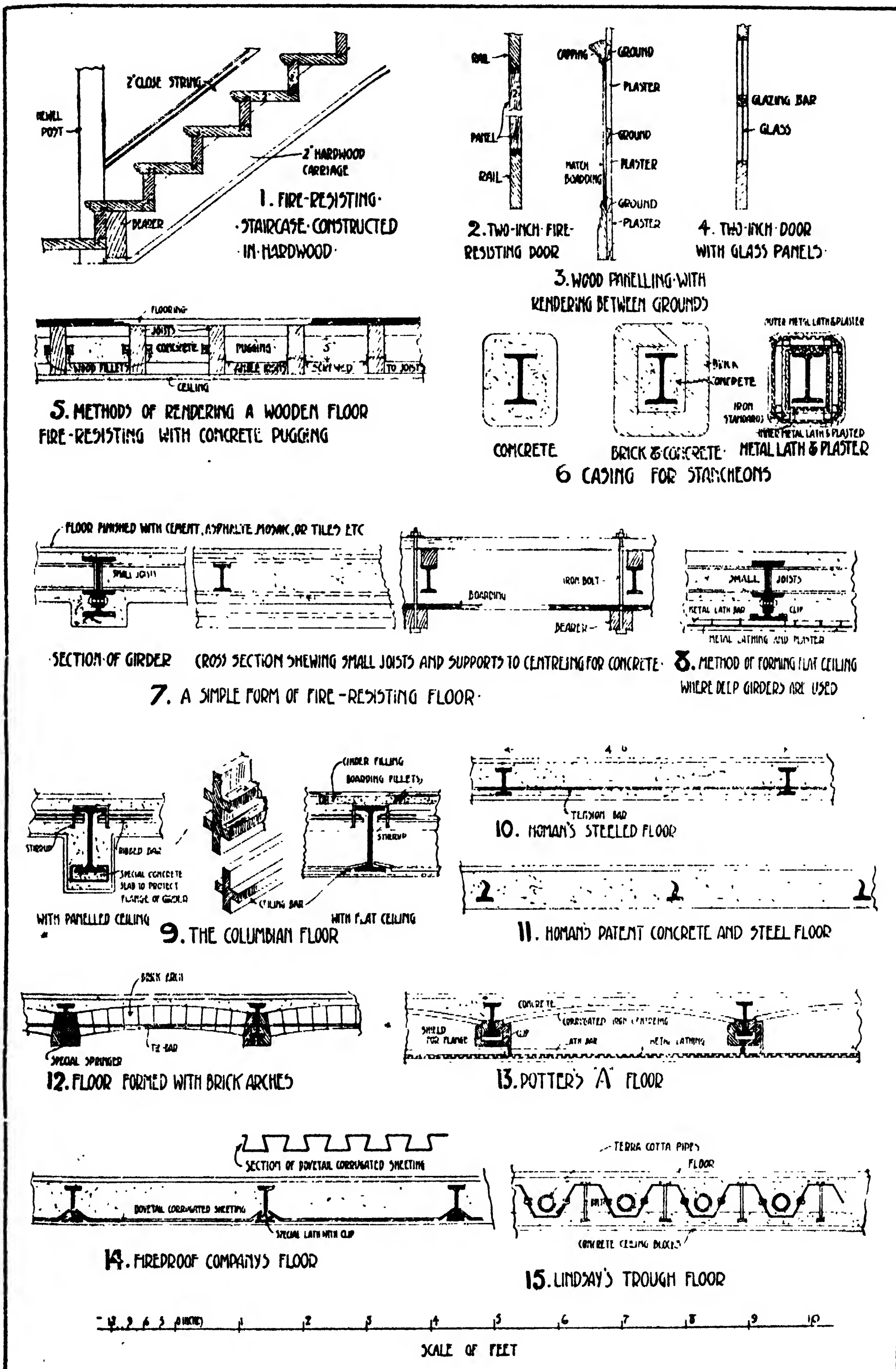
Of the material referred to as approved for special purposes, timbers of the quality known as "hard" are allowed in scantlings as thin as 2 in. ($1\frac{3}{4}$ in. finished) for the purposes scheduled, and this is a matter of great convenience, especially in alterations to existing buildings.

Precautions in Fixing Woodwork. In all cases where timber is employed in large or small scantlings it is desirable, as a protection against the spread of fire, to avoid all cavities behind such timbers or pieces of framing; they should be bedded as solidly as possible. Where bearers or battens are required for fixing joinery, linings, etc., to walls, the surfaces between them should be plastered flush with the surface [3], which greatly checks the tendency for fire to spread along such material. The outer face will, of course, burn and char, but this action will not penetrate far if the wood is attacked only from the face. On the other hand, if the fire once gets behind, and can attack both faces, wood, if in thin scantlings, is readily destroyed. Fire may easily and quickly work round behind a skirting or framing if any small air current is set up, and thus promote the spread of the conflagration.

Projecting Shops. In the case of the floors and roofs of projecting shops, and when, as the result of alteration of user, the ground-floor of a building has to be separated from the upper floors by fire-resisting materials, the system of construction described, in which concrete not less than 5 in. thick is filled in between the existing wood joists, is recognised as fire-resisting.

In any case in which this system is used in practice it is necessary to ascertain that the joists are adequate to carry the increased load with safety, and if this is not the case, they must be strengthened by flitches or iron plates bolted to the side of the joist, by a girder reducing their clear span, or by some other means of strengthening the construction.

Glass. Glass is recognised as fire-resisting only within somewhat narrow limits; it is, of course, incombustible, and melts only at a high temperature. The danger connected with its use is due mainly to its liability to crack if subjected to sudden changes of temperature or to lateral pressure, especially when used in large sheets. In work of a fire-resisting nature, therefore, the minimum thickness and the maximum dimensions are rigidly fixed, and



FIRE-RESISTING CONSTRUCTION

importance is attached to the nature of the frame which carries the glass. Where the latter is of wood, the breadth of any glazing bars should not be less than the minimum thickness required—that is, 1¾ in.—a bar that is thin laterally being as dangerous as one thin in the other direction [4]; but where hard wood beads are used for glazing, it will, in most cases, suffice to include them in the general breadth if they are properly fixed.

For glazing, ordinary plate or rolled plate glass may be employed; but *wired glass* is also manufactured, in which wire netting is embedded in the thickness of the glass; this glass is supplied in different qualities, but of a uniform thickness of ¼ in., and includes a clear glass; such glass is liable to crack, but will not fly to pieces or fall out.

The Luxfer Syndicate supply fire-resisting panels of glass made up of small squares or other forms of ¼-in. glass united by small strands of copper deposited by an electro-chemical process, and the whole surrounded by a stout copper frame.

Construction with Fire-resisting Materials. We have dealt with certain general considerations affecting fire-resisting structures, and materials specially adapted for use in such work, and we may now pass to the consideration of the various methods of construction adopted for different parts of such structures.

Main and Cross Walls. The main party and cross walls differ but little from those of ordinary buildings which, as already pointed out, are usually required to be constructed of fire-resisting materials and of adequate thickness. In this, as in all other matters, the provisions of the Building Acts or By-laws which are in force in the district where the building is to be erected must be consulted, and any requirements laid down in them must be complied with. Special care must be taken to see that the construction is solid, and all timber should, if possible, be excluded from the walls.

Internal Walls. The thickness of internal division walls is not usually regulated by Acts or By-laws, but depends on the work to be performed. In fire-resisting buildings it is desirable that there should be some division walls at least, thick enough to subdivide the interior into distinct compartments; this tends to delay, and may prevent the spread of fire. In buildings of great size the use of such division walls is enforced; the limit of size of any building being restricted in London, with certain exceptions, to 250,000 cubic ft., unless subdivided by party walls into two or more sections no one of which exceeds this amount in extent.

Protection of Iron and Steel Supports. These supports usually take the form of columns or stanchions of cast iron, or of built-up stanchions of wrought iron or steel. These may be encased solidly so as to be entirely surrounded with concrete, or with concrete filled in behind some other facing of superior quality, such as brick or terra-cotta [6]. Where columns and hollow stanchions are used, these may be filled with cement concrete with a view to preserving the iron from rusting. The main advantages of this solid treatment are that in the event of any damage to the outer face or casing there is less chance of the fire coming into contact with the iron than where a cavity is left: but it is necessary, in order to avoid undue heating of the iron, to make the covering thick, and this increases the weight and bulk of the pier. Every part of the ironwork should be covered with at least 4 in. of protecting material, and this must on no account be reduced for chases, pipes, wires, or any other purpose. The angles of solid concrete piers should be rounded, forming a bullnose of at least 2½ in. radius; this protects the angle from damage and resists the action of spalling when heated better than a square angle. A solid brick casing may be used round stanchions, the bricks being cut where necessary round the flanges. Such a brick casing is usually 9 in. thick, with splayed or bullnose angles. The outer face may be rendered more or less attractive in appearance, as occasion demands, by rendering the surface in plaster, or by using tiles or faience, or some other form of decorative facing.

Terra-cotta and Plaster Protection. *Terra-cotta*, formed with chambers, is often built up so as to enclose a stanchion or column, and may be formed of the hard-burnt, or of porous blocks [page 2781]; the latter are more fragile, but conduct heat less readily. If such a casing is built clear of the stanchion the air space in the chambers and between the terra-cotta and stanchion are serviceable in reducing the conduction of heat so long as the blocks remain undamaged, but if broken, so that the fire can enter, the advantages are lost, and the chamber round the stanchion may form a kind of flue, along which the fire may pass. Solid blocks of porous terra-cotta of considerable thickness are used in some cases, but in all these various methods of encasing iron supports the filling in of any cavity between the casing and the support itself is desirable. Plaster on metal lathing is sometimes employed, but alone is not a very efficient protection, as plaster is apt to *spall*—that is, to disintegrate and fall off in small pieces under the action of fire and water; if employed, two thicknesses of plaster should be made use of, with a clear space between them [6]. The innermost layer must be clear of the stanchion, and may be kept from it by small steel channel irons, or by solid metal laths, to which the lathing to receive the plaster is attached with wire. After this is plastered, similar small channels may be used to form the interval, and they also receive and support metal lathing, which is secured to them, and afterwards plastered, and, if necessary, finished in some ornamental manner.

The girders supported by these piers, which are to carry walls, must be sufficiently cased before the walls are erected on them. This may be done by surrounding them with concrete, or specially prepared blocks of terra-cotta may be used to protect the flanges, and on the outside the stone or brick facing may be finished close against the web; but it is essential that these main girders

should be as efficiently protected from the action of fire as the supports themselves. The protection of girders carrying floors will be dealt with in connection with the construction of floors.

Formation of Floors. The method of forming the horizontal divisions in a building that is to be fire-resisting is one of great importance, as it is even more difficult to prevent a fire from spreading vertically than laterally. The special treatment of certain floors by filling in concrete between wood joists, which can be looked upon as securing only temporary protection, has been dealt with. Another system that has been used, and found to resist successfully the action of fire, is to use fir joists, not spaced at intervals, but placed side by side, and bolted up, so as to form a solid layer of wood 5 in. or more in thickness, according to the span. An ordinary boarded floor may be laid on this, and the soffits may be plastered if the edges of the joists are rebated with dovetail rebates, to give a key for the plaster. Staircases with treads thus built up have also been used successfully. Concrete, formed with suitable ingredients, is one of the most important materials used in fire-resisting construction, but, except for very moderate spans, cannot be relied upon without steel or iron to assist in carrying it, owing to its inability to withstand much tensile strain. There are various forms of construction, apart from the varieties known as ferro-concrete [page 1454], in which floors formed of concrete are carried by iron joists, which are in turn protected by concrete or by some other material.

Floors of Concrete and Iron or Steel. The simplest form of such a floor is formed with a series of small rolled joists of iron or steel resting on supporting walls or carried between main girders; the joists are usually spaced not more than 3 ft. apart. A platform, formed with bearers and joists carrying boards laid flat and close together, is required, on which the concrete may be deposited, and which is left till the concrete is well set. Such a platform may be strutted up from below, like an ordinary centre, but may also, where iron joists are employed, be very easily suspended by bolts from cross-pieces packed up from the joists [7]. This form of centering is a great convenience, because the floor below is not encumbered with struts, and, as soon as moisture has ceased to drip from the cement, work may, if necessary, be carried on there. The striking is also easily carried out by slacking the bolts. The centre must cover the entire area to be concreted, and may, if necessary, be constructed so as to show some panels in the ceiling; but it should be fixed so that nowhere is there less than 2 in. between the soffits of the joists and the upper surface of the boarding. When the centre is ready, the concrete is spread evenly over the boards; care must be taken to see that it is well packed under the bottoms of the joists and in between the flanges, so as to ensure complete protection. It is desirable that the upper flanges of the joists should be covered by the concrete, or that at least the concrete be brought up to the level of the top of the upper flange. The concrete should be allowed ample time to set before the centre is either eased or struck. The actual time will depend on the nature of the concrete, but seven to ten days, at least, should be allowed. After the centering is removed, the concrete is left with a fairly smooth surface, and it is sometimes necessary to hack it over, if it is to be rendered in cement or plaster, in order to secure a proper key. This floor is of simple construction; it is extensively used, and is satisfactory where there is no necessity for using joists of any great depth.

Protection of Main Girders. When the small joists are carried in turn by deeper girders, these latter also require protection, and this is done in a variety of ways; but there are two principal methods of dealing with them in most methods of construction. The first is to encase the portion of the deeper girder that projects below the general ceiling level, so that the ceiling is formed into a series of sunk panels, separated by these encased beams [7]. Where the beams can be symmetrically arranged, such a treatment is satisfactory from both a practical and an artistic point of view. The second method is to conceal these beams by means of a ceiling suspended below them, or supported by the lower flange [8].

Various modifications of this simple form of floor have been introduced, of which some examples are given.

The Columbian floor substitutes for the ordinary H-section for joists a special section [9]. This bar is rolled in different sizes for different classes of work, and is suspended from the upper flange of the main girders by means of specially-made stirrup pieces. These bars are entirely encased by the concrete. Where panelled ceilings are to be formed, the lower flanges of the deep joists are protected by concrete slabs suspended from them by strips of metal inserted in the slabs when cast and bent down to grip the flange, and the sides are afterwards encased in concrete. Where a flat soffit is required, the ceiling is first formed with concrete 2½ in. thick, in which 1-in. bars are embedded, the ends bent up somewhat to allow of the bar itself being below the level of the flange. When finished, the upper floor is formed on centering resting on the ceiling below, and openings are left through which this centering may be withdrawn, and which are afterwards closed with slabs.

Homan's Floors. Two varieties of these floors may here be referred to. In the first of these, ordinary H-iron joists are used, but the webs are perforated at intervals just above the lower flange, and steel tension rods passed through them [10]. These are surrounded by the concrete, and assist in taking up the tensional strain, which the concrete is not well adapted to resist. In the second form of floor, T-irons are used, the flange being placed downwards, and the web not being straight in vertical section, but bent or corrugated [11]; but both of these are of the nature of ferro-concrete, and tend to reinforce, not merely to carry, the concrete.

Floors Formed without Temporary Centres. There are many varieties of floors designed to do away with the use of

temporary centering and at the same time to economise the amount of concrete employed. In all of these iron and concrete are the essential materials for the floor, but in many of them terra-cotta is introduced in the form of lintels. Several of these lintels were described and illustrated in the article on Terra-cotta [page 2781]. The use of these lintels may be described in more detail, and the difference between several forms of such floors is mainly in the character and form of the lintel employed.

Fawcett's Floor. This is formed with ordinary iron or steel joists placed at intervals of 2 ft., and these may be fixed before the lintels are placed in position. The lintels are tubular in section, and in plan are in the form of a rhomboid designed so that the shorter diagonal is at right angles to the direction of the girders, and this allows of the lintels being raised from below and swung into position. The lintels [127, page 2781] have flanges which, when in position, touch each other laterally and are also in contact with the ends of other lintels in the bay on each side. They form a continuous platform, on which the concrete can be deposited, and cover the lower flange of the girder.

The tubular form given to the lintel, which is provided with longitudinal projecting ribs, is a source of strength to it, and it is necessary that the lintel be strong enough to support the concrete, which is filled in between and around the lintels, until it has set. It performs also another useful function in reducing the mass of concrete, but at the same time permits of a considerable depth of concrete in the spaces between the tubes. At these points also the concrete gets a direct bearing on the flange of the girder at each end, and when once it is set, the lintel is no longer any appreciable source of strength to the floor; but the flat soffit is useful for forming a ceiling, and is provided with dovetailed grooves to give a key for plastering, and the girder protection which, with the rather thin, porous terra-cotta flanges, is none too complete, is thus increased.

Homan's Fireclay Hollow Brick Floor. This has somewhat similar lintels, but they are rectangular in plan, and in cross-section take the form of a triangle or a truncated triangle [127, page 2781]; they also form, by means of the lower flange, a continuous platform, which passes below the lower flange of the girder, and protects it. The material, which is fireclay, tends to make this protection efficient, and a very considerable proportion of concrete is saved by this form of floor. The soffit may be plastered.

Dawnay's Solid Tile Floor. This also makes use of lintels, but they are not tubular, but of a form that resembles somewhat the section known as *bulbiron*—a broad lower flange, a web, and a somewhat bulbous upper flange [127, page 2781]. The concrete is filled in between the webs, and obtains a bearing at each end on the joist, the flange of which is protected by the lintel, the soffit of which may also be plastered. In all these forms of floors their efficiency for fire-resisting depends on the lintels remaining unbroken, so that the lower flanges of the girders remain protected.

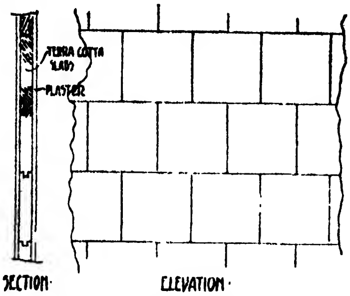
Some forms of floor, instead of employing long lintels reaching from joist to joist, use terra-cotta blocks arranged as a flat arch with springers, formed so as to fit in the flanges of the girders [see illustration on page 2781], and concrete is filled in on the back. Terra-cotta springers to protect the flanges may also be used with brick arches between the joists; but both of these forms necessitate a somewhat thick floor, and the use of iron ties between the girders to prevent lateral spreading from the thrust of the arches [12].

Floors with Iron as Centering. There are several forms of floors in which iron in some form is made use of as a centering. This may consist of corrugated iron, as in Potter's "A" floor, in which the sheets are bent so as to have a slightly arched form [13]. In this floor the lower flange of the joist is protected by two blocks of fireclay, which rest on the flanges on each side of the web, and meet below the flange and protect it; they also form springers to receive the iron centres. Special iron hangers are also provided, the upper ends made to fit over the top of the springer, the lower ends turned at right angles, and with a perforation on each just above the bend, through which a steel lath is passed. From these laths metal lathing is suspended and a plaster ceiling is formed, giving a double protection to the ironwork.

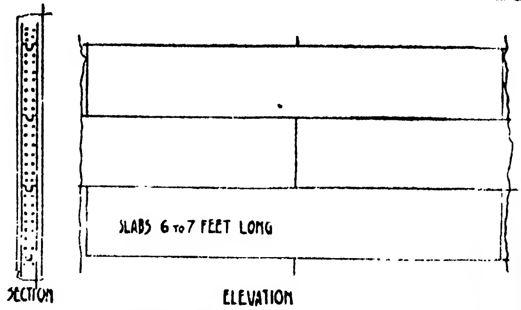
Dovetailed Metal Lathing. Another form of iron centering is dovetailed metal lathing. This consists of a thin, continuous sheet of metal, bent by special machinery into a series of dovetailed grooves, which form a continuous series of keys for plaster or concrete on either side of the sheet [14]. This material has many other uses in fire-resisting work, but when used for flooring, the sheets, which are usually 3 ft. wide, have the two edges bent up, so that when laid between the flanges of two girders, the general surface of the sheeting drops below the level of the girder flange, and to give a key under the flange a special metal lath with serrated edges is fixed.

Concrete is filled in on the top of the sheeting, and fills the dovetailed grooves on the upper side, while those on the under side give a key for the plaster or rendering of the ceiling, which forms in this case the only protection to the flange of the joist. Large girders may be efficiently protected with the help of this material, which may be fixed round the girder in the form of a boxing, the space between the girder and the boxing being filled with concrete, and the outside rendered or plastered. The dovetailed lathing materially adds to the strength of the concrete, and allows of the joists being spaced further apart than is the case with many floors.

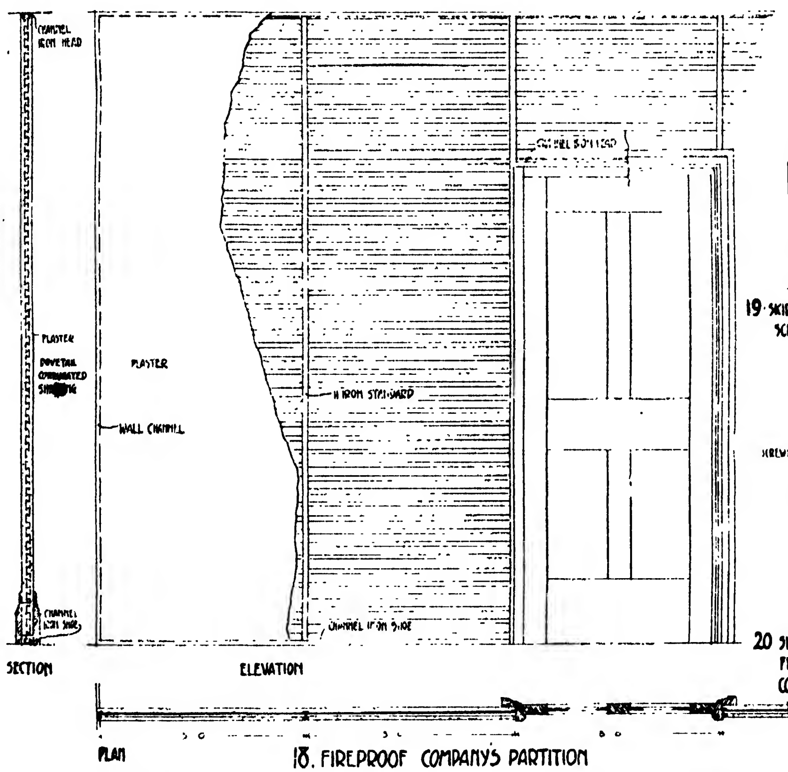
Lindsay's Trough Floor. This differs from those previously mentioned, as it depends for its strength almost exclusively on the ironwork, the concrete being used to protect the latter [15]. The ironwork consists of a series of troughs the sides of which are inclined at an angle of 120°, and the sides are rolled lighter in section than the bottom. In constructing a floor the alternate troughs are inverted and the sides bolted or riveted to the sides of the adjoining



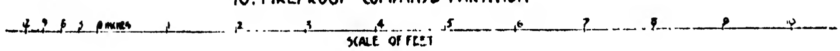
16 'TERRAWODE' PARTITION

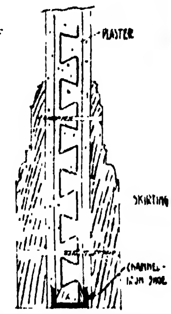


17 'MACK' PARTITION

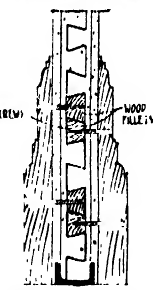


18. FIREPROOF COMPANY'S PARTITION

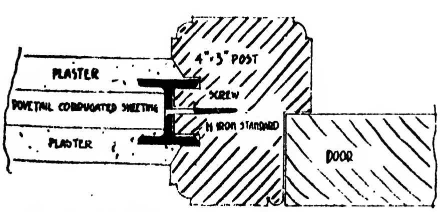




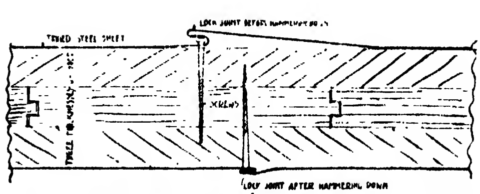
19 SKIRTINGS FIXED WITH SINGLE SCREWS FROM SIDE TO SIDE



20 SKIRTINGS SCREWED TO FILLETS IN DOVETAIL CORRUGATED SHEETING



21. METHOD OF FIXING DOOR FRAME IN FIREPROOF COMPANY'S PARTITION



22. MESSrs MATHER & PLATT'S ARMOURED DOOR IN SECTION SHEWING METHOD OF FASTENING STEEL SHEETS

troughs, producing a series of ridges and furrows, and forming an enormously strong floor; this is used in engineering work mainly, but is useful to the architect and builder where a floor of no great depth is required for a wide span. Concrete is filled into the upper furrows, and pipes of earthenware or terra-cotta may be introduced to reduce the bulk of the concrete and to afford passage-way, if necessary, for pipes, wires, etc. Where it is required to protect the under side of the floor, concrete blocks of special form are made with bolts embedded in them, by which they are suspended from the flooring.

Finishing the Soffits. Except in work where the question of appearance is only of the slightest importance, the under side of the ceiling requires some treatment which will give it a smooth and even appearance, or possibly an ornamental character. It may be finished in plaster with mouldings and enrichments, or in fibrous plaster, or sheeting of stamped steel; but it is undesirable that the plaster should be the only protection to the steel work as, under the influence of heat, it is apt to spall; this tendency is increased by the application of a jet of water. But when proper protection has been secured by the use of terra-cotta blocks, concrete, etc., plastering very usually forms the most ready means of treating the soffits effectively.

Finishing the Floor Surface. It has been pointed out that it is desirable for fire protection that the upper flanges of the girders should not be higher than the level of the top of the concrete, and this matter has an important bearing also on the method of flooring. From the point of view of fire protection, a floor laid solidly on the concrete is the most satisfactory, as it affords no air space in which the fire can spread; but to make this possible it is essential that the flanges of the main girders as well as the cross joists shall not project upwards above the concrete. Where such a flat surface is secured it may be floated over in cement and covered with a granolithic cement, tiles, mosaic, or blocks of wood, with asphalt or even stout linoleum for internal use, and with asphalt or vulcanite for external use. Where wood is employed for floors, hard wood is most suitable, though deal and pine, if laid in blocks 2 in. in thickness and quite solidly, will form a satisfactory floor. The methods of laying these various floors have been, or will be, described in other parts of this course.

Wood Joist Floors. In cases where the joists stand above the level of the concrete it is impossible to lay a solid floor, and the usual method is to lay wood sleepers parallel to the line of the joists, and deep enough to stand above the level of the top of the flange; on these, which may be at any convenient interval apart, but usually about 6 ft., wood joists are laid, and a grooved and tongued boarded floor. It is essential that the space between the floor and the concrete be efficiently ventilated, otherwise dry rot will almost certainly arise; but if ventilation is provided, and the fire attacks the floor from above, its spread will be greatly facilitated, and this form of floor should be avoided in buildings where full protection is desired.

Roofs. The efficient construction of roof with a view to fire-resistance is of the utmost importance, and has sometimes been neglected where other parts of the structure have been efficiently dealt with. It is not sufficient that a roof should be formed with non-combustible materials, though this is an advance upon the common form of roof, the construction of which is carried out wholly in timber, much of it in small scantlings, covered probably with boards carrying some non-combustible roofing material. But the cost of dealing with roofs so as to render them fire-resisting bears a higher proportion to the cost of an ordinary roof than does the cost of a fire-resisting floor to an ordinary one. It is a very difficult matter to protect adequately the members of an iron or steel roof, framed with tie rods and struts, and this can hardly be done unless the truss falls in the line of a partition. Partly to render protection easier and to provide for carrying the heavy load due to the use of concrete, very strongly framed roofs having the general form of a mansard roof [see CARPENTRY, page 4253], but usually with a flat top, are adopted. These are framed with iron of H-section, with plates at the angles and a tie beam at the floor level, and are often arranged to embrace two stories with an upper tie beam at the level of the upper floor. Such principals are arranged at convenient intervals not many feet apart, and between them joists of small section, corresponding with the joists in a floor, are fixed; the concrete is filled into the panels thus formed, covering the small joists and carried round the principals to protect them. This may be filled in on a temporary boarded centre or on a permanent metal centre, such as the dovetailed metal lathing.

Coverings for Concrete Roofs. In this construction, which may also be applied to domes and other forms of roof, it is important that the outer surface of the concrete in the slopes and the upper surface of flats be in a uniform plane, as in the case of floors, so as to receive the roof covering. This covering may be of asphalt, which is best laid in two thin coats, and may be used for flats and sloping surfaces; or of vulcanite, which is used for flats only, or even of cement rendering, but the last is not so permanent or reliable as the others, but is cheaper. All these are laid directly on the concrete. For sloping roofs, tiles or slates may be employed, laid on the concrete or on battens or on fillets of breeze concrete. Where a flat is adopted the surface must have a slight fall to throw off any water; if the flat is not extensive this may be formed by thickening the concrete over part of the area to give a slope to the upper surface; but with a wide flat this would involve too great a waste and weight of concrete, and the fall is provided in the framing of the truss, and a suspended ceiling must be provided to give a horizontal internal surface.

Vertical Partitions. External party and cross walls have already been dealt with, but with many buildings it is convenient and necessary to subdivide large floor areas into separate rooms by means of slighter partitions, which shall nevertheless be fire-resisting, the aim being to endeavour to confine any outbreak of fire to the compartment in which it arises, where it may be more easily dealt with, or may possibly burn itself out.

In some classes of buildings, such as office blocks, these internal partitions are not planned with the main walls, but large floor areas are provided that may be afterwards divided up. In these, and in other cases where numerous partitions are employed, it is important that they should be light, and no thicker than is essential for efficiency, as considerable economy of space and weight is thus secured. But to be thoroughly fire-resisting, a thickness of 3 in. is generally desirable.

Partitions of Built-up Blocks. Various forms of partitions are made, formed with terra-cotta blocks, which are in some cases hollow. These are made of light porous terra-cotta, and are built up to form a thin wall; they are usually provided with some form of flange to interlock, and some of them are provided with iron rods, as stiffeners, which pass vertically through the blocks. These allow of rapid construction, and, if the faces are plastered, form partitions capable of resisting the spread of fire for a considerable time. Partitions are also formed with slabs of solid material, used in the same way as brick, such as terra-cotta, of the porous sort already described, or of various patent compositions or forms, such as *Terrawode* or the *Mack* partition.

Terrawode is a light porous terra-cotta, made by a patent process. The material is produced in the form of bricks, which are of standard size, but about half the usual weight, and which may be laid in mortar like ordinary bricks, and plastered. It is claimed for this material that it is not only highly fire-resisting, but it is also sound proof, and that nails may be driven into it for fixing. It is also supplied in the form of slabs for partitions [**16**] and stanchion casing, the beds of which are grooved and tongued; these are set in lime putty, and may be plastered. Lintels for fireproof floors for use either with or without concrete, are also made of this material.

The Mack Partition This is built of slabs of gypsum, and in them reeds are embedded, running from end to end of the slab, which is made 6 ft. or 7 ft. long, and 1 ft. high, and 2 in., $2\frac{1}{2}$ in., or $2\frac{3}{4}$ in. thick [**17**]. The lower edge is provided with a half round tongue, which is knocked off in the case of the lowest slab before bedding it, and the upper edge has a hollow groove, which occurs also in both ends. The slabs are bedded in plaster, and the heading joints grouted in plaster, and they may readily be cut to any required length. The reeds give cohesion to the mass of plaster, and make it light. When stopped against door frames, a fillet may be spiked to the frame, to fit into the groove, which may be grouted. The surface of the block is keyed for plaster, or may be formed with a finished face both sides.

Thin slabs are made for ceilings from $\frac{5}{8}$ in. to $1\frac{1}{4}$ in. thick, also 4-in. and 5-in. slabs, with large circular perforations running the length of the slabs, to lighten it in addition to the reeds. The 5-in. slabs are specially manufactured for rendering timber joist floors fire-resisting, as already described [**5**].

Metal Lathing. Various forms of metal lathing may be used, strained between non-combustible supports, usually of iron, which are protected by the plaster or cement rendering with which the lathing is covered.

The dovetailed metal lathing, manufactured by the Fireproof Company, already mentioned, makes a very solid partition [**18**]; standards are provided of H-iron section and plates, heads, and wall pieces of channel iron; these are arranged to form a series of panels, and sheets of this lathing are fitted in between them, the grooves running horizontally. In fixing, these require to be carefully secured in their proper position, relatively to the standards, by vertical screeds of cement at each standard, which must be allowed to set before the general surface is plastered or rendered. The rendering is thick enough to cover not only the lathing, but the standard and rails.

Where openings occur for doors and borrowed lights, solid frames are used, which may be fixed to the standards with screws before the lathing is plastered [**21**]. Skirtings of wood will be avoided where the most complete protection is sought, but in many buildings they are employed, and may be fixed by means of screws driven through the partitions into the back of the skirting on the other side [**19**], or to hard wood dovetailed strips, cut so as to fit one of the grooves in the sheeting, and inserted before it is put into position [**20**]. Where required, picture rails, dado rails, etc., may be fixed in the same way, the strips taking the place of ordinary grounds. The plaster or rendering may be taken over them, so that they are not, under any circumstances, exposed to the action of fire.

Uralite. This is a material of comparatively recent introduction that is used for covering partitions, and may be used for external and internal work. It is composed of asbestos fibre cemented by mineral glue, and has been extensively used for all sorts of fire-resisting purposes. It is prepared in sheets 6 ft. by 3 ft. and in thickness from $\frac{7}{64}$ in. to $\frac{3}{8}$ in., and also in strips 3 in. wide. It is made in a hard and a soft quality, and finished in different colours, and may be obtained combined with a veneer of wood. When used for external walls, the sheets have the vertical joints carefully butted and nailed, the nails being from $2\frac{1}{2}$ in. to 3 in. apart, and the joints may be rubbed down and stopped with ordinary stopping. The horizontal joints are lapped $1\frac{1}{2}$ in. to 3 in. For internal partitions, horizontal and vertical joints may be butted, rubbed down, and stopped. Increased protection is given by covering the timbers of the framing with strips of soft uralite 3 in. wide. When used on roofs, greater care is required in protecting the joints. The horizontal joints are lapped 4 in. to 6 in., and the butt joints are covered with hard, waterproofed strips

bedded in white or red lead. Tilting pieces and cover pieces are supplied in uralite, but ridges, etc., are formed with zinc, tile, slate or iron.

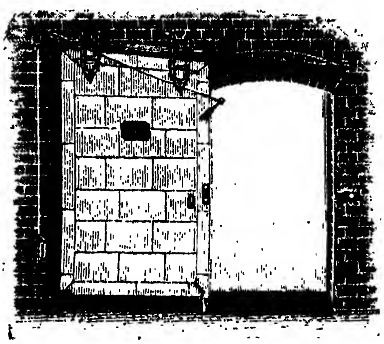
A somewhat cheaper material, in which asbestos is mixed with Portland cement, is made by the same firm, and is known as Kent slab; it is slightly thicker, and becomes very hard. It is applied in the same way.

Openings in Fire-resisting Walls. The openings in fire-resisting walls and partitions, however carefully dealt with, seriously diminish the fire-resisting qualities of the structure. Fire is readily spread by means of such openings, and where the efficient protection of valuable property requires the greatest possible precautions, care must be taken to prevent fire spreading through them, not only within a building through its doors, but, in the case of narrow streets and areas, from building to building through the windows.

External openings are the most difficult to deal with, because they are of necessity large, to give adequate light when used by day. Any screens or shutters closing such openings must be capable of being opened to their full extent, so as not to obstruct the access of light.

Sheet iron was at one time used for such purposes, but unless the edges are very firmly held, such doors are liable to twist, and may even force out the fixings from the walls. Any door which twists and ceases to lie flat against the frame or jamb of the opening will allow air to pass, and with the air flames or inflammable gas. A shutter or door, 2 in. thick, of hard wood, will resist the attack of fire for a considerable time if it fits close in a frame with a deep rebate; but the metal hinges and fittings used with such doors are apt to become red-hot and destroy the wood around them in time, and become loose, and they should, therefore, be firmly bolted through, not merely screwed.

Forms of Fire-resisting Doors. Shutters formed with a frame of channel iron, in which two sheets of corrugated iron, made with very small corrugations, are fixed, and the space between them tightly packed with slag wool, have been employed. Both shutters and doors are now frequently built up of wood, and covered with sheets of tinned steel The illustration [23] shows such a door made by Messrs. Mather & Platt. The doors are formed of two or three thicknesses of deal tongued and grooved and nailed together. They are covered with the tinned steel sheets, which have welted joints [22], and are fixed with screws which are covered by the joints and do not show; this allows the sheets to expand, but not to become loose. Such doors may be arranged to swing or slide; the swing doors are fixed with strong strap hinges, and are provided with double latches, so that the door is held near both top and bottom. Sliding doors have strong hangers, by which they are suspended from a metal runner, and by giving an inclination to the runner they may be made self-closing. When intended to act automatically, these doors are fitted with a counterpoise, attached by an inflammable cord. On the burning of this cord the door will close by its own weight; but this may occur too late to prevent the passage of fire, and to ensure complete protection care must be taken to provide for closing regularly all such doors and shutters nightly. A guide must be provided both at the top and bottom of the door to ensure its keeping close to the wall, and when closed its edge should fit into guides near the top and bottom, and overlap the opening by at least 3 in. all round. It is a great advantage to have a sill provided against the bottom of the door or wall as for the head and jamb.



23. AUTOMATIC CLOSING DOOR (Mather & Platt)

Doors are also made in this form with a layer of uralite placed between the woodwork and the steel sheathing. A door of this kind can hardly be made an attractive object, and when appearance is of importance wooden doors may have to be resorted to, and though they do not give so thorough a protection as an armoured door, may, if carefully constructed, offer a continued resistance to fire for a considerable time.

Built-up Wood Doors. The flush-framed, 2 in. hardwood door has already been described. Another form is one built up of three thicknesses of wood securely fastened to each other with wood pegs to avoid the use of nails on unprotected surfaces.

The *Gilmour* doors are framed with a core of pine, not used in boards, but in thin strips glued together side by side. The core is surrounded with asbestos sheeting nailed to it, and upon this a veneer of oak is glued and pressed under hydraulic pressure. Both flush-framed and panelled doors may be formed in this way. A panelled door with panels formed in the same way and only ½ in. thick resisted the action of a fire which attained a temperature of from 1,500° to 1,600° F. for 50 minutes when tested by the British Fireproof Committee

Greatly increased protection is afforded by using doors in pairs, one on each face of the opening to be protected, forming a small lobby between the two which is entirely lined with incombustible materials.

FIRE-RESISTING CONSTRUCTION *concluded; followed by* SLATE AND TILE WORK

CROMWELL & HIS SUCCESSOR

Continued from page 4553

The Republic and the Restoration. A Tremendous Personality and the Force Behind It. Some Famous Events in the Reign of Charles II.

By JUSTIN McCARTHY

CROMWELL at last brought the civil war to an end, his closing work being accomplished in Ireland, where the severity and cruelty of his repressive measures make his memory there odious to this day. The contest with his Parliament he brought to a sudden end by forcible expulsion in 1653.

The Commonwealth. Being anxious to give some aspect of constitutionalism to his rule, he summoned a Puritan Convention, or Assembly, which promptly received the nickname of "Barebones Parliament"; but even this convention could not work in harmony with Cromwell, and the "Barebones Parliament" was also dismissed, and Cromwell was declared Protector of England on December 16th, 1653. A sort of constitution was drawn up which provided that the government of the country should consist of a single ruler, with one House of Parliament and a Council of State, the members of which were to be named by the Protector, but elected by the Parliament. The Protector was to be allowed the right of passing legislative measures while Parliament was not sitting, and this right was much used by Cromwell for the rapid carrying through of measures which seemed to him necessary. When the Parliament, such as it was, met again, several members raised questions as to Cromwell's exercise of authority, a difficulty which Cromwell met by excluding all members who refused to accept its conditions.

The next Parliament which was summoned proved their devotion to him by actually offering him the title of King. Cromwell seemed at first inclined to give the proposal some consideration, but the great majority of the soldiers on whom he mainly relied were Republican, and he ultimately declined the title.

Cromwell's Difficulties. He next restored the Upper House of the Legislature, and the grateful Parliament voted him a fixed revenue, and installed him as Protector. But when Parliament met again there began a struggle between the two Houses, whereupon Cromwell resorted to his familiar policy and dissolved it on January 20th, 1658. From that time he rested his authority on the support of the army.

Cromwell's political troubles were as great as before. He had constant evidence that there were schemes going on for the organisation of armed movements on behalf of the Royalist cause. Under different conditions Cromwell might have made a successful and beneficent arbitrary ruler, but the endeavour to obtain anything like a compromise between religious hostilities, between the advocates of monarchy and the advocates of republicanism, was too much for him. He was able, however, to declare Scotland and Ireland to be part of the British kingdom, giving to both a nominal right of representation in Parliament.

His foreign policy had made England more powerful in Europe than ever she had been before. He concluded many treaties advantageous for England, and made the Commonwealth the leader and the guardian of Protestant Europe. He endeavoured to form a league of the Protestant States of Europe against all opponents, made peace with Holland, and protected the Waldenses and other small Protestant populations against the oppression of Catholic sovereigns. The victories of Admiral Blake, in 1656, over the Spaniards, against whom Cromwell had allied himself with France, brought fame and money to the Commonwealth.

The Rule of One Strong Man. His was the rule of the one strong man, and so long as he lived it seemed to be firm and secure in England. But the time had gone when such a rule could be long maintained over the English people, and the man himself was soon to pass away. Cromwell had worn out his vigour by incessant over-exertion, while he had long been suffering from heavy maladies. On September 3rd, 1658, his life came to an end in the sixteenth year of his reign. After the Restoration his body was disentombed, was actually exposed on a gibbet at Tyburn, the public place of execution for malefactors, and was then buried there. The Commonwealth which Cromwell had created, and which he alone could have maintained, passed out of existence almost immediately after his death.

The great Protector had three sons—Robert, Oliver, and Richard—but the second and the eldest son had died before their father, and he nominated Richard as his successor. But the work of maintaining the Commonwealth would have been too severe even for a man of the highest statesmanship, and Richard Cromwell was not such a man. He had no capacity or inclination for rulership, and he had only just entered on the Protectorship when army and Parliament alike showed impatience at his attempt to rule. Seeing that the crisis was beyond his control, he abdicated in May, 1659.

Reaction. After the death of Richard Cromwell the country was broken up into factions. Military government fell asunder when the one man who could have sustained it was removed from the living scene. The supporters of the Stuarts were still powerful, and the legitimate successor to the throne of England, Charles II., was ready for the restoration of Royalty. Under the conditions of such a time it was but natural that the reaction from the Commonwealth should look to the restoration of the Stuart dynasty as the only hope for the re-establishment of peace and order. The

hour was propitious for a change, and the man soon came forward. This man was General George Monk, afterwards Duke of Albemarle. Monk was a soldier of much and various experience. He had seen service for some years in the Dutch army, and, returning to England, commanded a regiment to suppress rebellion in Ireland. He was employed to complete the subjugation of Scotland, and soon after he won two great battles at sea over the famous Dutch Admiral, Van Tromp, England being then engaged in one of her wars against Holland.

The Restoration. After Cromwell's death, Monk, who was then Governor of Scotland under the Commonwealth, crossed the border on New Year's Day, 1660, with an army of 6,000 men, and straightway marched upon London, which he entered without opposition. His intention was to restore the Stuart dynasty, and he speedily realised that if he made a determined effort he would have the majority of the nation with him. He played a dexterous part in endeavouring to make a compromise with the supporters of the Commonwealth; but he soon proclaimed himself the champion of the Stuart restoration, and invited Charles II. to return to England and claim his throne. On May 26th, 1660, Charles landed at Dover, and the national revolt against military despotism secured him the throne.

Charles was born at St. James's Palace, on May 21st, 1630. After the death of his father he spent a wandering life abroad, although he made several attempts to regain the thron He escaped to France, where he spent some years, and afterwards to Germany and the Low Countries. Then, at length, came the death of Cromwell, the hopeless attempt at rule of Richard Cromwell, the movement of General Monk, and the restoration of Charles II. to the throne. But Charles was not the man to turn to good account the great chance which fortune had thus forced upon him. His main desire was for a life of luxury and amusement, and he was unfitted to be the ruler of a state. He was for many years greatly under the influence of Edward Hyde, Earl of Clarendon, the lawyer, statesman, and historian, whose influence injured the popularity of Charles with his own people and brought him into small and meaningless wars. In one of these, the war with the Dutch, Commander De Ruyter actually sailed up the Thames and destroyed some warships then lying at Chatham. Under the influence of Clarendon a peace was made with Holland which left both England and Holland in financial straits, and raised France once again to a high and commanding position.

The Cabal Ministry. After the downfall of Clarendon, Charles, under the influence of the "Cabal" Ministry—composed of Clifford, Arlington, Buckingham, Ashley Cooper and Lauderdale—entered into a secret treaty with France, and became a pensioner of Louis XIV. The feeling against France was all the time becoming stronger and stronger in England, and he was compelled to consent to the marriage of his niece Mary with William Prince of Orange.

The greatest man of the reign was, perhaps, John Milton, the influence of whose poems and prose works alike told heavily against the development of that spirit of selfish and sensuous indulgence by which it was distinguished.

Plague and Fire. Among the distressing events of the time were the Plague of 1665, which caused the death of some 70,000 persons in London alone, and the Great Fire of the following year, which destroyed nearly 14,000 houses in London. Another event of the reign was the famous "Popish Plot" of Titus Oates, who, in 1678, professed to have discovered a scheme among the Catholics for the wholesale massacre of Protestants, the burning of London, the assassination of the King, and the occupation of Ireland by a French army. Titus Oates became, with the popular party, the hero of the hour, and on his evidence, and that of other informers, many leading Catholics were tried, convicted, and imprisoned or executed. On November 30th a Bill was passed for "Disabling Papists from sitting in either Houses of Parliament." In March, 1679, the Bill to exclude the Duke of York from the throne was brought in. It was deferred by the King, but was passed through the Commons in the November of the following year and rejected by the Lords. In December, Lord Stafford, the most notable victim of the Popish Plot, was executed. But the tide soon turned against Oates; he was sentenced to imprisonment for life, and only released after the Revolution of 1688.

Habeas Corpus Act. The one really great measure with which the reign of Charles II. is associated is the passing of the Habeas Corpus Act, founded on Section 29 of Magna Charta—"For the better security of the liberty of the subject." This Act, which was passed in 1679, provided that any person imprisoned by the order of any court, or even of the sovereign, may have a writ of habeas corpus to bring him before one of the regular courts of law, which should consider the case and decide whether the committal was just or unjust. It was also provided that the Act could be suspended by Parliament for a specified time in any national crisis or emergency.

There were some victims to panic and passion in the reign of Charles II. whose names must for ever be treasured with honour in England. One of these was Lord William Russell, third son of the Duke of Bedford, who at the Restoration was elected a member of the House of Commons. This was during the famous conspiracy known as the Rye House Plot, a plot to murder the King and the Duke of York at the Rye House, in Hertfordshire. It was formed by some of the extreme Whigs in 1683, after the failure of the Exclusion Bill. The plot failed, but although the charge against Russell, Sidney, and Essex was entirely unfounded, they and others were convicted and sentenced to death.

Charles died on Friday, February 6th, 1685, leaving no children by his marriage with Catherine of Braganza, daughter of John of Portugal, in 1662.

Continued

THE HOSIERY FACTORY

Warp Frames. Circular Hosiery Frames. A Series of Circular Knitting Frames. Improvements and New Inventions in Hosiery Machines

Continued from page 4622

By W. S. MURPHY

ONE limitation is natural to the hosiery machine; every knitting frame is constructed to produce a particular class of work. When a weaver wishes to change the kind or character of the fabric he has been weaving into something different, he requires, as a rule, only to change the mountings of his loom, and sometimes not even so much. The knitter, on the contrary, constructs his frame for a given kind of fabric, and cannot change it except at very serious cost. This fact partly explains why there are so many hosiery machines.

Warp Frames. Most knitting frames are constructed to manipulate a single thread; but when Crane, of Edmonton, invented his warp frame in 1775, he brought a new and highly important principle into the hosiery trade. Henson thus describes the machine: "The star boxes and falling bar were taken away from the common stocking frame, and the lockers were fastened up to prevent the jacks from falling. A series of guides, of the same number and gauge as the needles of the frame, with holes in their ends, were fixed on a bar near the heads of the needles. At the top was a warp beam furnished with as many threads as there were needles, and a machine to guide these warp threads to the needles, each passing through its own guide. A part of the machine was adapted to make each thread to form a loop like that which schoolboys make on a string. This alone would have produced only a series of looped strings. But by other movements a spring was applied, and the guides were removed one needle to the right or left at pleasure; and the same movement being repeated in looping, the two next and every next loop was conjoined to its fellow loop. By removing the guides two or more needles to the right, and then working the same number of courses to the left, a knitted web was produced of zigzag angular texture, and varied coloured stripes could be made."

The Value of the Warp Frames. No one who considers attentively the structure of this machine can fail to be struck with its singular adaptability to all cloth-making purposes. When James Tarrat, a famous mechanic, added treadles to the frame, in 1785, and otherwise increased its productive power, it was generally perceived that a great step had been taken in the production of knitted fabrics. Not only so, but the basis of the machine lace industry was laid when this machine was constructed. Rotary power was applied to the warp frame chiefly through the invention of William Dawson, a Leicester framework knitter, to whom the hosiery trade owes an immense debt.

Cotton's Warp Frames. Among the other numerous inventors who progressively assisted to develop the usefulness of the warp frame Luke Barton stands out as, perhaps, the most conspicuous till William Cotton, of Loughborough, gave the results of his genius and labours to the world. Cotton's warp frame, with improvements and additions, is one of the principal frames at present in use. Of the modifications, which scarcely affect the body of the frame, we shall not treat. The details of the frame itself are worth the closest attention, embodying as they do most of the ideas which are to be found in all our newest machines. The needles, instead of being horizontal, are set perpendicularly in front of the presser bar, which is stationary, and press themselves against it. On the old frames the sinkers are hanging on the jacks, but in this machine sinkers and jacks are separated. Placed behind the needles, the jacks are fixed on a wire, the ends over the slur bar, along which runs the slur cock, and forces them up. Furnished with round heads, the jacks, as they come forward, strike on the sinkers, bringing them down to form the loops. By the operation of a locking bar, the lead sinkers divide the loops with the jack sinkers; the needles are brought down to a lower level than the divided loops, the beards being presse' in the act; then the loops are borne over the needle heads by means of the fixed appliances. A new course is thus formed, and a range of stitches added to the web. The widening and narrowing apparatus consists of ticklers, finely adjusted as to obey a side movement, either way, the distance of one needle, in any gauge, and to remove or put on any number of stitches which may be required.

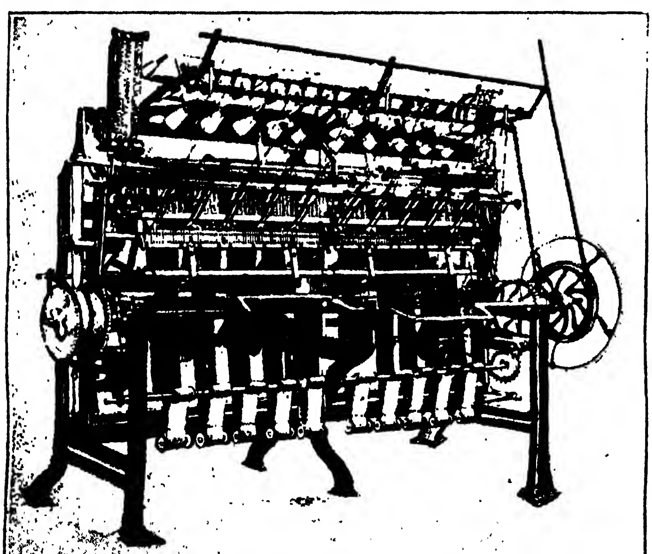
Rotary Rib-top Frame. This is one of the finest examples of the rotary machine [216]. As may be generally known, the ribbed heads of stockings, the gussets, wristbands, and other fittings of underclothing, are made separately, and joined on to the main pieces afterwards. On the rib-top machine, Strutt's ribbing appliance is made automatically perfect. The upright ribbing needles play in upon the horizontal needles of the frame with incredible rapidity, and fine accuracy. The action of the slur is reversed; it runs over, not under, the jacks, which are steadied by springs from behind. Sinker and jack are joined firmly together, or made in one piece, thus imparting to the former an accuracy of movement not attainable with the jointed sinker. All the operations in this frame follow each other automatically, whether forming the welt, putting in the splicing course, or striping.

Circular Hosiery Frames. The most popular knitting machine is the circular frame. Invented by Sir Marc Isambard Brunel, the great engineer, in 1816, as a mere pastime, probably to see if he could re-invent the knitting frame or not, it lay unheeded for nearly thirty years. Brunel is universally credited with the invention, but there is a serious dispute as to the merits and precedents of the improvers and introducers of the machine into the trade. A tradition exists in Leicester that a native of that town, named Griswold, made the machine really industrial; but Felkin, the supreme authority on the subject, traces a direct line of successive improvers, from Arthur Paget, of Loughborough, through Peter Claussen, of Brussels, Thomas Thompson, of Nottingham, Moses Mellor, W. C. Gist, and Edward Attenborough, down to thirty years ago. Later authors make the Bickford the standard circular machine. From America improved frames are brought over and patented year by year. Our business is not to adjudicate the claims of rival inventors, but to study the machines they have produced.

Brunel's Round Hosiery Machine. We elect to examine this invention out of no historical curiosity, but because the principle of this important class of knitting frames is most clearly exhibited in the original machine. The needles are of a common bearded shape, and firmly set on the outer rim of a wheel suspended from, and fixed to, a rotating spindle. The wheel may be of any diameter, and the needles, placed in a concentric manner, are set at distances varied according to the quality of work to be produced. Another wheel moves upon the spindle, carrying arms and knitting appliances, as well as the yarn which feeds the machine. As the thread is delivered it is pressed down between the needles by pallets and carried under the hooks. By an oblique movement the thread is pushed to the extremity of the needles by the first arm of the wheel described. The second arm carries a small wheel with long teeth like radii. The solid part of this wheel presses the needle beards into their grooves, and, taking the web, slides each stitch up to the heads of the needles. A third arm, carrying a wheel, throws the stitches over the hooks. Several sets of these wheels may be fixed round the spindle wheel.

Process of Improvement. Paget introduced an upright cylinder, with needles placed round and moved upwards in succession, the beards being subjected to a pressing motion as the needles returned to the lower position. Peter Claussen, besides making a new form of feed wheel, varied sizes of pressure wheels, and comb pieces, attached an apparatus for winding up the web. Thompson devised a ribbing appliance for the circular machine, and used the tumbler needle. Mellor placed the needles perpendicularly, and operated upon them from the outside by an indented loop-wheel roller. Attenborough produced a series of circular frames containing many improvements, which are in use at the present day. Similarly, a Griswold series has been developed, and is still operated.

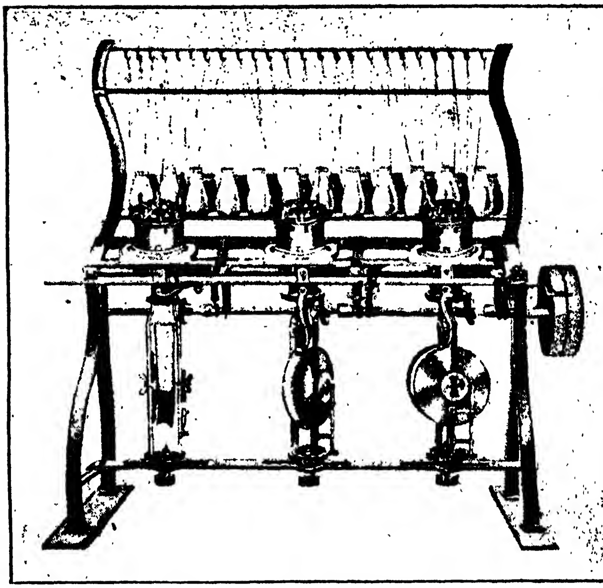
A Series of Circular Knitting Frames. Nowhere does the innate conservatism of the British character manifest itself so strongly as in the factory. Not that this implies lack of progressive power. Rather the contrary is the case. Side by side we can see the oldest and the newest models working together in the same factory. Here is a series of machines, looking outwardly very much alike. Spools of yarn are held aloft on slender rods, the threads coming down over guides to the rings of delicate needles. The first of the series is an old Griswold, with its ring of 80 needles sending out a coarse tubular web on to the winding apparatus below. Next we find another machine with movable needles. At a given point, the worker stops the machine and adjusts the needles to produce the curve of the leg on the stocking. Further along, a stocking-leg is almost complete; the worker switches off the drive, and moving the machine by hand, knits the heel of the stocking with a half-circle motion. At the last we come upon a machine, which, at the proper moment, begins of its own accord to form the heel, executing the to-and-fro reciprocating action necessary for the formation of the heel.



216. ROTARY RIB-TOP FRAME

An American Machine. The following is the specification of one of the many American circular frames which have been patented in Great Britain during recent years. "The method of forming full-fashioned stockings, which consists in taking up the full number of stitches required to form the top of the leg, knit-

ting a few circular courses, dropping a portion of the stitches, knitting a few courses on the remaining needles by feeding each yarn to the same row of needles in both directions throughout the said courses, thereby forming two short sections of flat webs; then throwing out of action one-half of the remaining needles, knitting a toe-bulge by knitting a given number of courses back and forth and narrowing, and then a corresponding number of like courses and widening, at the same time uniting the widened portion of the narrowed portion; then throwing into action the needles last thrown out of action; then knitting a sufficient number of circular courses to form the greater portion of the foot; then widening for several courses to form a gusset or gore in the bottom of the foot; then knitting the heel-bulge in the same manner as the toe-bulge, and upon the same side of the tube as the gusset or gore; then knitting a series of circular courses to form the ankle; then widening upon the same side of the tube as the heel-bulge till all the needles first thrown out of action are again in operation; then knitting a series of circular courses, using the whole number of needles to complete the whole desired length of the leg; then throwing out of action and dropping the stitches from the same needles that were first thrown out, repeating the foregoing operations as many times as said stops from the path of one rack bar to the path of the other rack bar, and vice versâ."



217. CIRCULAR HOSIERY FRAME

Mechanism of the Circular Knitter. The top of the frame [217] is a flat table, into which the bed-plate is fixed. Secured to the plate is the grooved needle-guide cylinder, and over it a loose ring, provided with thread-guides for conducting the thread to the needles. A revolving cylinder, with annular grooves interrupted by cam openings, clasps the needle cylinder. Adjustable cams raise and lower the needles, and other cams are set so as to reverse the knitting machine for forming the heel. A bevel-gear transmits the power from the driving crank to the cam-cylinder, and causes the machine to make a circular web. To fashion the leg certain needles are removed, and their loops placed on adjacent needles. In forming the heel the machine automatically draws up the needles on one part, leaving the needles required for the breadth of the heel, and the cam-cylinder moves to and fro with reciprocating motion instead of going directly round.

Calendering. The hosiery calendering machine is a simple roller press, designed to flatten down and give permanent form to the fabrics. "Leg-bags," especially, which require to be cut and footed, are put under pressure.

Cutting. Common hosiery of the cheaper qualities is woven in lengths equal to a pair of hose. In order to form the foot, these need to be cut in a very careful manner. On the cutting machine the tube is cut half way across, then a long cut is made down the length of the web for about 18 in., and the knife brought through again in a transverse direction. This at once separates the pairs and shapes the foot.

Seamers and Finishers. Many knitted fabrics and garments are made in parts, which must be joined together. This is the work of the seamers or menders. Being purely practical, and involving merely dexterity of hand and practical knowledge of each kind of article, this operation does not lend itself to teaching in the abstract. The same might also be said of hosiery finishing in general. To give anything like an adequate summary of all the dainty and delicate fabrics and garments which are made in the finishing department from the products of the machines would involve much study of little practical value. Every factory has its own specialities, and the forms of these alter year by year, season by season. In this department the hosier uses all kinds and classes of silk ribbons, cords, and various fancy smallwares. In many cases, too, the embroidery machines are called into requisition, especially in those factories whose enterprise touches nearly on the province of the gauze weaver at the one side and that of the lace manufacturer at the other.

Pressing. Many of the finer fancy goods and articles of underwear are passed through the steam-heated press. Like most of the hosiery finishing appliances, this press is very simple in structure. Both table and presser are shallow boxes of cast iron, compartmented, and filled with steam, which circulates through them. Subjected to the pressure and heat, the goods come out smooth, firm, and glossy.

Continued

Group 9
DRESS
33

MILLINERY continued from page 4568

PATTERNS & SHAPE-MAKING

How to Take Patterns from Models. Copying Shapes from Measurement. Shape-making. Shaping the Tip. The Process of Mulling

By ANTOINETTE MEELBOOM

THE advantage of being able to take patterns correctly is very evident, as the newest shapes are never "blocked" or sold retail.

A milliner buys the trimmed models, and takes the pattern of them to copy either in a wire shape or to cut out in espatra or buckram for firm shapes to be covered with cloth, velvet or silk. The experienced milliner is very quick at seeing what will be the best way to set about it, as in a much curved and trimmed hat or toque it is not so easy at first to get at the actual shape. It may sometimes be necessary partly to take off the trimming.

Taking the Pattern. A paper pattern is taken in three parts: the brim, the sideband, and the tip, each part being taken off before the next is begun to avoid tearing the paper. Unless it is a toreador, turban, pork pie, or pillbox shape hat—all of which have an edge to the brim—the brim pattern can be taken in one piece.

BRIM. The pattern is taken either from the inside or outside of the hat—whichever is more easy to get at. Take a piece of good tissue paper, place it with the corner to centre-front of brim, pin it with a steel pin, and smooth it away on either side until the brim is entirely covered without a wrinkle. Avoid placing the pins in a row, as that is likely to give fulness between [22]. Pin round the headline; cut away the paper round the edge, holding the hat in the left hand and the scissors in the right. See that the paper is cut *exactly* to the headline. Mark centre-front with small "snick" △.

Take out the pins, fold the paper in half, and see that the two sides are exactly alike; the edges may require cutting. (This applies to a plain hat with both sides alike.) In cheaper bought shapes of buckram and straw, which are often one-sided, select the side which appears the better shape, and mould the other half to that. If the paper is not large enough, or the brim is too much fluted to be taken in one piece, join on pieces wherever necessary.

SIDEBAND. For the sideband, start again from the centre-front, smooth and cut the paper wherever necessary on either side till it reaches the back [23]. Cut away along the top edge, and continue snipping the paper round the bottom till it can easily be cut away round the headline.

Snick for centre-front, and, in the case of the join coming at the side, snick also the centre-back. The join comes on the sideband wherever it is most likely to be covered with the trimming.

THE TIP. The "tip" of a hat is generally round, oval, or diamond, and it is therefore unnecessary to take the pattern, for when the sideband is joined to the brim the shape of tip can readily be found.

In toques and bonnets the pattern must always be taken, as there are so many kinds of fancy shapes. If the pattern is likely to be much used, run it on stiff net with fine cotton, cut the net to shape, and keep for future use, keeping all the parts of a pattern pinned together.

In "turban" [40] hat brims, the second edge is often merely a straight piece, in which case it can be measured and cut out in paper; if, however, it is ever so slightly shaped, a paper pattern should be taken.

ROUND DOME CROWNS [24]. No pattern is taken of these, as they can be made from a blocked shape.

OVAL CROWNS [25]. This shape may be taken in two pieces—the sides and tip.

TOQUES AND BONNETS. Patterns of toques and bonnets are taken in the same way as hats. Bonnets of the Dutch [26] or Marie Stuart [27] type may be taken in one piece. The *Coronet* is a fancy-shaped brim in the front side or back of a bonnet. Such shapes as the Granny and Véronique bonnets must be taken in separate parts, as described for hats.

ROUGH STRAWS. If it is impossible to take the pattern of rough or fancy straws in paper, use pieces of stiff net or leno of about 2 in. square. Lay the pieces on the upper side of brim, each overlapping a little, and pin down.

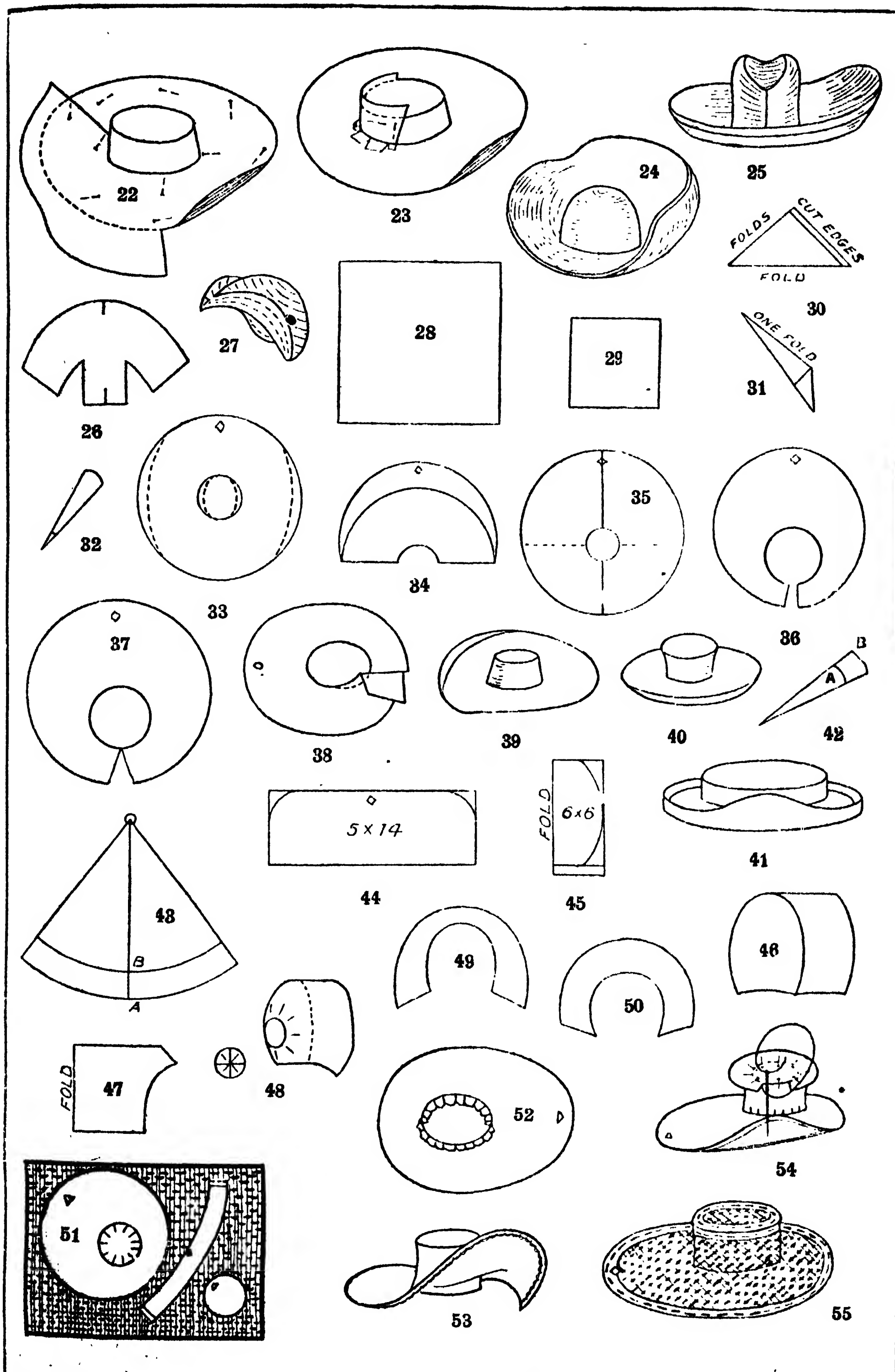
Cut the outer edge and headline of pattern to shape of hat, and make a snick for centre-front. Take pattern carefully from the hat. Pin this net shape on to a piece of paper or a large piece of net, and cut out the pattern again.

To correct the pattern, fold it in half and check it, modelling from the side which looks the better. If there is any difference in size at headline, keep the shape of that which has been less cut away.

If straight, take the pattern of sideband by measurement, having the join at back, and allowing no turnings.

Copying Shapes by Measurement. To copy a shape by measurement, which would be done if a wire shape is required, proceed in this order:

1. Headline. Pin the inch tape at the starting point, and work from right to left.
2. Outside edge.
3. Width of brim, centre-front, sides and back.
4. Diagonal of brim—(*a*) side-front right, (*b*) side-front left; (*c*) side-back right, (*d*) side-back left.
5. Diameter of brim—(*a*) front to back, (*b*) side to side.
6. Depth of sideband.
7. Size round tip.
8. Diameter of tip—(*a*) front to back, (*b*) side to side.
9. Width between wires round edge.



SHAPE-MAKING FOR HATS AND BONNETS. FIGURES 22-55

Take the measurements from the *inside* of model where possible, and make a note of any peculiarity of shape. If the pattern of a trimmed model is taken, measure all the trimmings, noting position of feathers, etc. Write them down in a notebook.

If an espatra shape is required, obtain the measurements and then take a large square of paper, fold it in half, draw the headline and cut it out. To obtain the radius, divide the size of head by 3, and this will be the diameter of the circle; halve this, which will be the radius. Open out the paper, mark all the different measurements from the headline. Proceed in the same way for the sideband and tip.

After some experience, it will be easy to make up one's own patterns, beginning in this way:

Cut a square of paper the diameter of the hat to be made [28].

Fold it in half, then in half again, thus making a square [29].

Fold it diagonally [30], and diagonally again, always keeping the folded edges of the paper together, and placing the new fold on the separate folds [31].

Cut off the triangle beyond the double part, slightly sloping it. If sloped too much, flutes will be formed round the edge [31].

Open it out, and it will be found to be a circle.

Refold, and from the centre point measure one-sixth of the headline, which should be cut off [32]. This gives a round brim with round headline, only suitable for children and young girls. For adults, the headline is mostly oval, which is obtained by sloping off ½ in. along each side [33].

To make a brim wider in front than at the back and sides, instead of folding the circle in half fold it 1 in. or 2 in. from the front [34]; refold, and cut headline as before [35].

For shapes like the Gainsborough [36], larger on one side than the other, cut the larger side first, and shape the smaller side *after* the headline is cut.

After getting the circle of paper with the headline cut out, any shape may be made, according to fancy. An oval-shaped brim may be cut by sloping ½ in. to 1½ in. away from each side.

Half an inch taken from centre of back, sloping to a point in headline, will cause the brim to turn up or down [37]. A gusset, inserted either at the left side or the side-back, will cause the brim to be very much curved [38].

Small cuts sewn together, slightly overlapping, will turn the brim up round edge, as for French sailor hats and similar shapes. Thus, with a little originality and ingenuity, any kind of shape can be evolved.

Sidebands. In making shaped sidebands more curve is required for those which are narrower at the top than at the bottom, and vice versâ [39 and 40]. The straighter the sideband, the less the curve should be. For a sideband that is nearly straight very little curve is required. Straight sidebands, not wider than 3 in., may be cut on the cross of the spatric, and slightly stretched top or bottom [41].

Take a square of paper of about 20 in. Proceed to fold it in the same way as for brim until a circle is obtained. Measure the depth of the sideband from outer edge, B [42]. Open paper out and measure along bottom the size of headline. Measure along the top, A, about 2 in. less and cut off along the curved lines. No pattern need be made of the tip as it is fitted to the sideband when the shape is made up.

Another method of obtaining the same result is to take a piece of paper, fold it in half, and mark the centre at top. Hold the end of a tape measure on this mark and make A at 15–18 in. down. Sweep to either side of A [43]. Measure upwards 2½ in. or 3 in., according to size required, mark B, and sweep round again.

Measure along curve from A half the size of headline. Mark each side and draw a line from the pivot to these points. Cut along the curved lines.

Fancy patterns of toque shapes should be made in wire from measurements taken. They would be difficult to copy in hard materials, as these do not lend themselves to such manipulation.

Children's hats and bonnets may be drafted from measurements. For hats, only one measurement is required—size of head. For bonnets there are four measurements: Over the head to below the ears, 14 in.; ear to ear, round back of head, 5 in.; forehead to nape of neck, 11½ in.; forehead to centre crown at back of head, 5 in.

Cut length of paper to correspond in length with the first measure and in width with the fourth measure [44]. Round the corners.

For the back of the bonnet, cut a square of paper the size of third, less the fourth measure [45]. Make a circle from the square. Fold it in half and cut off 1 in. to 1½ in. to form an oval.

Cut off 1 in. from the bottom. For "Coronets," with revers (the patterns of which are made separately) [49 and 50], place the front of bonnet flat on the table, pencil round the shape on paper and draw the shape and width required.

The cutting out, making, and trimming of the bonnet shown in **46**, **47**, and **48**, are described when dealing with Children's Millinery.

SHAPE-MAKING

Having learned to take patterns, we will proceed to make the shape. The best milliners usually make their own shapes, as they are much lighter, fit better, and possess more individuality. The block shapes bought in shops are turned out by the thousand, and are mostly made of an inferior kind of buckram, badly wired, and, in some cases, the different parts are only gummed together.

We will take first "winter" shapes, which have to be covered with velvet, cloth, silk or fancy millinery material. The best material for shape-making is espatra, known in the trade as "spatric."

It is made only in white in sheets 24 in. by 31 in., and in two kinds, stiff and soft. The stiff is used for straight or very slightly curved

brims and crowns. The soft spatrie is better for the curved brims of hats, toques and coronets of bonnets. It is easier to manipulate as it stretches; or can be eased on the wire. It also makes the shape lighter in weight. If espatra is not obtainable, millinery buckram is the best substitute, made only in black and white, and sold by the yard.

Open out the pattern and place it on the espatra with the front (which was marked in each piece with a "snick") to the corner. Remember that *all parts* are cut with the centre-front placed on the cross [51]. Pin the pattern firmly on the espatra, leaving these turnings: (1) Half-inch turning inside headline; (2) ¼ in. at each end of sideband.

If the brim is cut at the back [36], in order to overlap or sew in a gusset, leave ¼ in. turning each side.

Mark *on* the espatra the centre-front of each part; cut out and remove the pattern.

Making up the Shape. Snick the ½ in. turnings left inside the headline, ½ in. apart, and turn back to rough side, defining well the headline [52]. All parts of the shape must now be wired, using the wire stitch, one wire coming to two edges. Use firm support wire.

BRIM. Wire headline on rough side of espatra outside the turnings [52]. Overlap the wires for 2 in. wherever they join. Wire edge of brim on the muslin or smooth side of espatra at the extreme edge [53]. Sew another (liner) wire ½ in. from the edge on the under part of the brim. [53].

SIDEBAND. Pin centre-front to centre of front of brim, the smooth side of the spatrie coming outside [54]. Back stitch evenly all round to turnings of brim and over the wire, and stitch up the join. Wire *inside* the top of sideband at the extreme edge.

THE TIP. As no pattern is usually made for a hat tip a piece of espatra, rather larger than required, is pinned on sideband (with the cross of espatra to the front of sideband), smooth side uppermost [54]. Cut off about 1 in. at the time to shape of sideband and wire, stitching it as you proceed. When the half is done, start again from the centre-front.

Shaping the Tip. Great care should be taken to keep the tip a good shape, and not to cut away too much, or it will sink in, and prevent the covering from setting well. Dome crowns [24] are bought blocked ready made.

Oval crowns with a dip in the centre [25] have the tip rubbed and stretched in the centre to make the necessary dip.

Oval crowns without dip are cut from two similar pieces, wired on one side, and the other sewn to it.

When a brim has to be gradually curved, as in a Gainsborough or San Toy, the shape should be held on the arm, or some other soft substance, and the espatra gently rubbed with a thimble. Rub on the outside for an upward, on the underneath for a downward curve.

For a boat shape, in wiring the edge of brim the shape is slightly contracted.

For fluted brims the edge is slightly stretched in the wiring.

In shapes with crowns larger at the top than at the base, the crown is not sewn on until the upper brim is covered [40].

In some shapes with deep sidebands the brim is slipped over the crown, part of the sideband making the bandeau [53].

Bonnet shapes are made up in the same way as hat shapes, except that the outside wire must go all round, overlapping for 2 in. at the back. Cut the tip exactly to pattern, and the sideband with ⅜ in. turnings round the bottom. Cut the front or brim with ½ in. turnings round the head, snicking the turnings at regular intervals and folding them back to the edge of pattern to define the headline distinctly.

Wire-stitch a wire round the outside of these snicks, as for hat, leaving ½ in. of wire beyond each end. Pin the bottom of sideband round the headline of the front, beginning from the centre-front, and snick the ⅜ in. turning to make it set well. Then backstitch this round.

Wire the top edge of sideband inside, leaving ½ in. of wire at each side. Pin the tip round the top of sideband, and wire-stitch it on carefully.

Wire the edge all round, nipping on the ½ in. turnings left at the ends of the sideband and headline. Wire-stitch it across the back, overlapping the wire for 2 in. where they meet, and cut away any rough turnings that may be left inside.

To enlarge a bonnet shape, cut the pattern in the middle, leaving the sides the same shape, and add 1 in. or 2 in. in the centre of shape. If the sideband is also enlarged, it will make the whole band wider.

Mulling. Mulling is the process of covering the wires with mull muslin to prevent the wire and stitches marking the material. Cut strips of mull muslin on the cross, or sarcenet about 1 in. wide, turn in the edges, bind round the edge of brim and tip, using the long backstitch [55]. Mulling the tip must be done by two processes; first sew round the tip, and then round the sideband. It will not set well if the stitches are taken through both edges alternately.

For shapes to be covered with silk, crêpe, thin velvet or similar light millinery material, both upper and under brim and entire crown are covered with mull cut to shape, and the edges mulled as described above. Often the under brim only is mulled all over, in which case the wire ½ in. from edge of brim is omitted.

Continued

Continued from page 4634

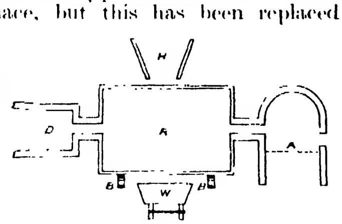
ALKALIES

Plant and Processes in Manufacturing Alkalies. Soda, Ammonia, Chlorine, Bleaching Powder, Chlorates, Phosphorus and Alum. Organic Acids

By CLAYTON BEADLE and HENRY P. STEVENS

THE operation we have described [page 4634], called the *salt cake process*, is the first step in a method of manufacturing carbonate of soda, first practically worked out by the Frenchman Leblanc, at a time previous to the Revolution. It is still largly used at the present day, although other methods, in particular the ammonia-soda, or Solvay process, have replaced it to a great extent, and now account for half the total production.

The pure salt cake, such as is prepared in muffle furnaces, consists of sodium sulphate, with only a small quantity of unchanged common salt, sulphuric acid, and other substances. The crude salt cake, prepared in a reverberatory furnace, contains about 96 per cent. of sodium sulphate, and for the next operation, termed the *black ash* process, it is mixed with an equal weight of powdered limestone, and three-quarters of its weight of coal. The limestone should be free from silicates, and the coal as free as possible from ash, both sources of silica, as the soda formed in this process reacts with silica to form sodium silicate, with consequent loss of soda. The mixture is placed in furnaces. The older type consisted of a reverberatory furnace, but this has been replaced to-day to a large extent by revolving furnaces [15]. The advantage of a revolving furnace is this, that the materials get uniformly mixed during the process, placed as they are inside a horizontally rotating drum, R, kept on the move; and further, the mixing is carried out mechanically, and hence a great saving of labour is effected.



15. REVOLVING SALT CAKE FURNACE

The Revolving Furnace. The revolving furnace is heated either by a flue from the furnace, A, or by "producer gas," which enters the cylinder at one axis, while the fumes and products of combustion escape from the other end of the cylinder, through the dust chamber, D. H is the hopper for charging the cylinder, which revolves on rollers, BB. The contents of the furnace can be emptied through a door, not shown in the diagram, into the waggon, W, underneath.

The chemical changes which take place may conveniently be represented as consisting of the reduction of the sodium sulphate by the carbon of the coal, or, in other words, the carbon combines with the oxygen of the sodium sulphate to form carbon monoxide and carbon dioxide, which burns or escapes while the sodium sulphate, bereft of its oxygen, and converted into sodium sulphide, remains behind.

Na_2SO_4	+	$2C$	=	Na_2S	+	$2CO_2$
Sodium sulphate		Coal		Sodium sulphide		Carbon dioxide

Sodium sulphide is produced in the presence of the limestone or carbonate of calcium, and immediately reacts with this substance. That is to say, the metals sodium and calcium change places with the formation of sodium carbonate and calcium sulphide.

Na_2S	+	$CaCO_3$	=	CaS	+	Na_2CO_3
Sodium sulphide		Calcium carbonate, or limestone		Calcium sulphide		Sodium carbonate, or black ash

As the operation proceeds, the pasty mass or black ash begins to get stiffer. In the last stages a good deal of carbon monoxide gas is given off, which burns, forming blue jets of flame. The appearance of these jets is an indication of the completion of the process. The black mass is removed as a lump or ball from the furnace. The temperature of the black ash furnace will reach 1,000° C., and as in the old form of furnace the mass had to be well raked over by hand the advantage of the revolving furnace will be evident.

Lixiviation of Black Ash. The third and last process consists of the separation of the carbonate of soda from the worthless sulphide of calcium. The former is readily soluble in water, but the latter is insoluble, so that the black ash is lixiviated—that is, extracted with water—in tanks, hence the term "tank liquors." These tanks are usually provided with perforated bottoms. The denser sodium carbonate solution passes through the perforations and is drawn off continuously, leaving the calcium sulphide, or "tank waste," behind. Sufficient water must be led into the tanks to keep the ash always covered. It is one of the peculiarities of chemical changes that they are frequently liable to reversion—that is, to take place in the opposite direction. The agencies which effect a change in chemical composition tend to retard this change by reversing the process directly one or other condition of affairs preponderates. To put this diagrammatically, the body AB reacts under one set of conditions with a body CD to form bodies AC and BD. If, now, we change the conditions, AC and BD will react together again to form the original AB and CD. Now, if A represents sodium

and B sulphur, C calcium, and D the group CO_3, we have a case of reversion before us. In the black ash furnace sodium carbonate and calcium sulphide are formed; during lixiviation there is always a tendency for the sodium carbonate to react with the calcium sulphide, giving sodium sulphide and calcium carbonate, so that it is of importance to conduct the lixiviation as rapidly as possible. Nothing conduces to this more than a porous ash, and to get the ash into this condition the quantities given above of limestone and coal dust are used, although they are in excess of what is necessary theoretically. In practice one half as much limestone and almost twice as much coal dust are taken as would be required in theory. The coal dust decomposes some of the limestone, forming carbon monoxide. This is why the blue jets of flame appear at the end of the process. The gas, escaping as the ash cools, fills it with tiny holes and renders it porous.

$$\underset{\text{Limestone}}{CaCO_3} + \underset{\text{Coal}}{C} = \underset{\text{Caustic lime}}{CaO} + \underset{\text{Carbon monoxide}}{2CO}$$

At the same time a certain quantity of caustic lime (CaO) is formed which slakes in the presence of water and acts on the solution of sodium carbonate to form caustic soda.

$$\underset{\text{Caustic lime}}{CaO} + \underset{\text{Water}}{H_2O} = \underset{\text{Slaked lime}}{Ca(OH)_2} + \underset{\text{Black ash or sodium carbonate}}{Na_2CO_3} = \underset{\text{Calcium carbonate}}{CaCO_3} + \underset{\text{Caustic soda}}{2NaOH}$$

Recarbonation. This caustic soda has to be recarbonated by allowing the liquors to descend carbonating towers, up which passes carbon dioxide gas from limekilns. At the same time, other impurities such as sodium sulphide, silicate and aluminate are decomposed, with the formation of sodium carbonate. The carbonated "tank liquor" is concentrated in iron pans which are provided with mechanical scrapers; the black salt which separates out tends to adhere to the sides and bottom of the pan. This "black ash" consists of monohydrated carbonate of soda ($Na_2CO_3.H_2O$). This after ignition yields the "anhydrous" (water free) carbonate of soda or soda ash. Sometimes the evaporation of the tank liquors is carried only far enough to bring about the separation of crystals, which are then removed from the mother liquor (red liquor). If the soda ash be dissolved in water and a little bleaching powder added, traces of iron, etc., will be precipitated. Crystals separated from the concentrated liquor yield "refined alkali" on ignition.

Caustic Soda. If, however, caustic soda be required, there is no need to reconvert the caustic back to carbonate, but the tank liquors obtained by treating the black ash with water, which may contain as much as 20 per cent. of caustic, or the red liquors are diluted and causticised by heating in iron vessels with slaked lime. The reaction which brings this about has already been explained.

This, again, is a reversible action, and reversion takes place more and more the greater the concentration of the liquor. To get a good yield of caustic, the liquor must be dilute, say 15 deg. Twaddel, or 7·3 per cent. of soda ash. The weak caustic liquor is run off from the deposit of carbonate of calcium and concentrated in iron vessels. To complete the destruction of traces of sulphate and other impurities from the tank liquor, a little nitre is added in the stages of concentration. [For further details of causticising see Soda Recovery under PAPERMAKING.]

Recovery of Sulphur. It will be seen that in chemical manufacturing operations, the by-products are made use of wherever possible. Thus, the by-product in the salt-cake process is the valuable substance—hydrochloric acid.

The by-product in the black ash process is of very little value, and enormous quantities of it accumulate in the neighbourhood of the alkali works, where it becomes a nuisance. Many attempts have been made to utilise it, and a satisfactory process was eventually worked out by Chance. In this process carbon dioxide is allowed to act on the calcium sulphide, which is decomposed with the liberation of sulphuretted hydrogen. The sulphuretted hydrogen is burned with a limited supply of oxygen, sufficient only to convert the hydrogen into water, while the sulphur is deposited as such. Of course, the gas can be burned completely with the formation of water and sulphur dioxide if required for use direct in sulphuric acid works.

The Ammonia-soda Process. We have described the old Leblanc process by which considerable quantities of alkali are still manufactured. Were it not for the valuable by-product—hydrochloric acid—formed in this process, it would have given place to the ammonia-soda process even more than it has done. With the improvements in electrolytic processes for making chlorine and bleaching liquors, one of the main outlets for hydrochloric acid—namely, the production of chlorine—will disappear. There is a considerable demand for salt cake and for hydrochloric acid (for pickling iron), but to all appearances the Leblanc process for working up the salt cake is doomed unless greater economies should be effected in working.

The ammonia-soda process possesses several advantages:

1. There are no malodorous by-products difficult to dispose of.
2. Soda ash is obtained directly in solid form.
3. The products are considerably purer.

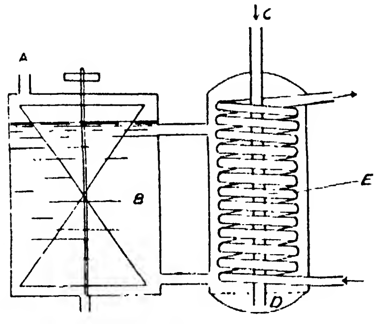
Theory of the Process. It has long been known that carbon dioxide gas passed into a solution of ammonia in brine brings about the precipitation of bicarbonate of soda, but, as in all such cases, there were numerous failures when attempts were made to apply this principle on a large scale. The problem was eventually solved by a Belgian—Solvay—and the process is frequently known as "The Solvay Process." On ignition the bicarbonate of soda splits off carbon dioxide gas, leaving soda ash behind

$$\underset{\text{Bicarbonate of soda}}{2NaHCO_3} = \underset{\text{Soda ash}}{Na_2CO_3} + \underset{\text{Carbon dioxide}}{CO_2} + \underset{\text{Water}}{H_2O}$$

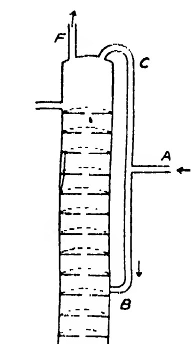
Theory Applied to Practice. Concentrated brine is saturated with ammonia gas obtained from gas liquor [see Coal Tar Products].

The carbonic acid gas is obtained in the first place from limekilns. The saturated solution of brine is run into a tank fitted with a false bottom, and the liquor saturated with the gas [16]. The brine is run into the reservoir, B, with the addition of sufficient lime to precipitate any iron, alumina, etc. The liquid then passes to the adjoining vessel, the saturator, where it is saturated with ammonia gas driven in through the pipe, C, and, passing to the bottom of the vessel, is distributed by the perforated false bottom, D.

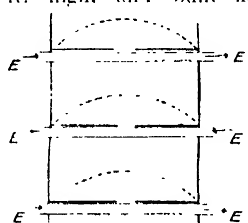
In the course of this operation much heat is evolved, and, to prevent loss of ammonia, which is a very volatile substance, the tank is provided with coils of tubing, E, through which cold water passes. From this tank, the brine, now saturated with ammonia, passes to a settling tank, and is thence pumped up into carbonating towers, where the liquor is treated with carbon dioxide gas, by which bicarbonate of soda is precipitated [17 and 18]. These are iron towers some 50 ft. or 60 ft. high, and built in sections, each section forming a drum 6 ft. across and 3½ ft. high. Between each section is a plate provided with a wide opening, and resting on this a perforated cover full of small holes and convex in shape, like an inverted watch-glass. The tower is also traversed by a number of tubes, EE [18], through which cold water flows for the purpose of keeping down the temperature due to the chemical reaction taking place. If allowed to get too hot, considerable loss of ammonia would result. The brine enters the tower rather more than half way up [B, 17]. The branch, C, is merely for the purpose of equalising the pressure. The carbonic acid is pumped in at the bottom, D, and, rising up through the tower, is caught and broken up into a number of streams of bubbles by the perforated plates, so that a large surface of the gas is exposed to the action of the brine liquor. As it will carry away with it mechanically some of the ammonia, sufficient space is left in the upper part of the tower for these two to combine to form carbonate of ammonia and to descend into the liquor. In spite of this precaution a small quantity of ammonia will be carried away with the excess of carbonic acid through F, and to effect recovery of this valuable substance the gases are led through two scrubbers, the first containing water, and the second dilute sulphuric acid.



16. BRINE SATURATOR AND RESERVOIR FOR THE AMMONIA SODA PROCESS

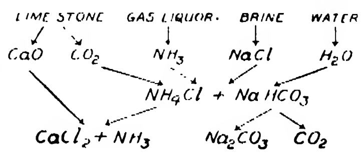


17. CARBONATING TOWER IN AMMONIA-SODA PROCESS



18. DETAILS OF CARBONATING TOWER IN AMMONIA-SODA PROCESS

The Cycle of Reactions. It may as well be pointed out here that the ammonia is the expensive ingredient in the process, and as it is not used up, but only plays the part of a contact substance, means must be devised, which we shall consider presently, for recovering the whole of the ammonia, and using it again. The part played by the ammonia in the ammonia-soda process is similar to that of the nitric fumes in the sulphuric acid chamber process. The reaction between carbonic acid and the brine, in the presence of ammonia, causes the separation of the bicarbonate of soda. We give a diagrammatic representation of the ammonia-soda process.



Limestone burnt in kilns yields lime and carbon dioxide. The latter combines with the ammonia from gas liquor and salt from brine to form ammonium chloride and sodium bicarbonate. The ammonium chloride is decomposed by the lime (from limestone) giving calcium chloride, which goes to waste, and ammonia, which is used over again. The sodium bicarbonate is ignited, and yields carbon dioxide for use over again and carbonate of soda.

The minute crystals of bicarbonate are heavier than the liquid, and gradually sink to the bottom of the tower, whence the liquid is withdrawn through H, thick and muddy. This liquor contains bicarbonate of soda in suspension, also some ammonium chloride and excess of sodium chloride. The sodium chloride forms a quarter of the total quantity taken—it goes to waste, as it does not pay to recover it. This is preferable to losing more of the ammonia, which would be the case if it were attempted to utilise the salt completely. The muddy-looking liquor is put through sand filters, where the granular crystals are separated, or the separation may be effected by a centrifuge. The crystals and mother-liquor are introduced into a rapidly rotating sieve. The mother-liquor is driven through the sieve by the centrifugal force, but the crystals, being too large to pass through the holes, are

retained. The crystals of bicarbonate of soda are next washed with water. The washings, of course, containing much of the bicarbonates, as well as traces of salt, ammonium chloride, etc., are used over again with the brine.

Although bicarbonate of soda finds extended use as such, nevertheless, for many purposes, the carbonate is required. All that is necessary to obtain it is to calcine the bicarbonate. Half of the carbonic acid is easily driven off, leaving a mass of pure carbonate behind, and the carbon dioxide may be used again for carbonating the ammoniacal brine. Carbonate of soda prepared in this manner has one disadvantage over that obtained by the Leblanc process. It is specifically much lighter, the density being 0·8, whereas the density of the Leblanc product is 1·2. This increased bulk raises the cost of carriage very considerably.

Ammonia Recovery. In order that the ammonia-soda process may be worked economically, it is absolutely necessary to recover the ammonia. The residual mother-liquors from which granular crystals of bicarbonate have been separated contain chloride of ammonia, carbonate of ammonia, and a common salt. They are introduced into a column, or dephlegmator. This contrivance consists essentially of a tall tube or column divided into compartments not unlike the carbonating tower. It is situated over the still in which the liquors are heated. The volatile gases, together with steam, pass up the column, which is constructed to bring them into frequent and close contact, so that the less volatile steam has every opportunity for condensing and returning to the still, while the more volatile ammonia passes over.

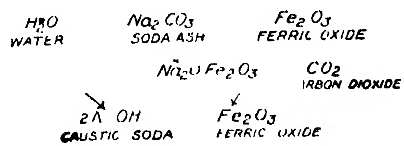
The ammonium carbonate is sufficiently volatile of itself, but to obtain the ammonia from the ammonium chloride lime is added to the contents of the still. This reacts in such a way as to produce calcium chloride and free ammonia. The residue of calcium chloride in the still and excess of salt goes to waste. This plant works on the same principle as that we shall shortly describe and illustrate for making ammonium sulphate from gas liquors.

Working Details. Owing to the separation of the crystals of bicarbonate in the tower, the holes in the plates gradually get clogged, and every week or ten days the tower must be emptied, and the bicarbonate washed out by letting in hot water or steam. In the improved process this is, to a certain extent, got over by using double carbonating towers. The first tower is smaller than the other, and in it is prepared neutral carbonate of ammonia. This may be regarded as the first stage in the chemical changes which produce the sodium bicarbonate. It is also that in which most of the heat is liberated, so that this tower is the one which requires to be effectively cooled.

The contents of the second carbonating tower should not be kept cool, as the best temperature for the precipitation of the granular bicarbonate is 35° C. If the temperature be higher, too much bicarbonate remains in solution, while, if lower, ammonium chloride and ammonium carbonate tend to separate out with the sodium bicarbonate.

Caustic Soda by Loewig's Process. A new method for the conversion of sodium carbonate into caustic soda was devised by Loewig, and is particularly applicable when worked in combination with the ammonia-soda process. The carbonate of soda (three tons) is intimately mixed with ferric oxide (one ton). The latter substance is a common iron ore. The mixture is heated to a bright redness in a revolving (black ash) furnace, when carbon dioxide is given off, and there remains behind the caustic soda in combination with iron as sodium ferrite.

The mass can be extracted with cold water to remove any impurities, and the remaining material is then decomposed with hot water (90° C). The action of the hot water is to reconvert the iron into oxide, which settles out, and to leave the caustic soda in solution. As carried out on the lines of the Hewitt-Mond patent, some 92 per cent. of the soda is causticised, the remaining 8 per cent. being unacted upon. By this means the caustic liquor is obtained much stronger (58° to 62° Tw.) than by the lime process, so that a considerable saving is effected in concentrating. As the concentration proceeds, the 8 per cent. carbonate which has escaped causticising separates out, so that the resulting caustic is practically free from carbonate. Further, no lime is required, and the product is much purer and free from other salts



Carbonate of Soda. We have followed out the manufacture of this substance on a large scale by more than one process, and have familiarised ourselves with the forms in which it appears in commerce. We have explained the manufacture of black ash in the Leblanc process, and the soda ash obtained from it. We have also seen how soda ash can be obtained directly by igniting bicarbonate of soda.

Soda ash is anhydrous—that is, free from water—and contains only a trace of caustic soda and other impurities. The best commercial varieties contain 98 to 99 per cent. of the pure substance.

It has been pointed out that in the Leblanc process caustic soda is formed at the same time as carbonate of soda. This is no disadvantage when required for many purposes, such as soap-boiling, etc. The caustic is not removed, and a variety known as caustic ash, containing 20 per cent. of caustic soda, is sold. If carbonate of soda be obtained as crystals deposited from a solution, we obtain soda crystals ($Na_2CO_3 10H_2O$), or common washing soda. On account of the large quantity of water present, the crystals contain much less soda than the soda ash, but they are much purer, and form the common household soda, which contains

only 37 per cent. of anhydrous carbonate of soda. Soda crystals, as sold, have been considerably adulterated of late, and a conviction was recently obtained against a trader for selling a mixture of crystallised carbonate of soda mixed with Glauber's salts (or sulphate of soda) as soda crystals.

Adulteration of Soda. We have already made ourselves familiar with the sulphate of soda in the form of salt cake, and know that this substance has neither scouring nor cleansing properties. It is evident that the lady of the house was badly put upon when she bought soda crystals adulterated in this manner. The case in question was brought before the Court of Appeal in November, 1905, and soda crystals have now been definitely defined as crystallised carbonate of soda ($Na_2CO_3 10H_2O$). If the soda crystals be prepared by the Leblanc process, it is quite possible that they will be contaminated with a trace of the sulphate of soda from which they were prepared; but this should not exceed 1 per cent., or at the most 2 per cent.

To test for the presence of Glauber salts in washing soda, a few crystals should be crushed up and treated with dilute hydrochloric acid until no more gas is evolved. To some of this solution a little barium chloride solution should be added, and the liquid warmed, when any Glauber salts present brings about the formation of a white precipitate of barium sulphate. This precipitate will be heavy and copious in the case of a really adulterated sample of soda crystals. There is no excuse for the presence of much sulphate of soda in soda crystals, as these two substances cannot be made to crystallise together without a great deal of trouble. Under ordinary conditions the carbonate crystallises and separates out first, excess of sulphate remaining in solution.

Baking-powder. Besides carbonate of soda, we have met with bicarbonate of soda, the main product in the ammonia-soda process. This is a white powdery substance, and as it contains twice as much carbonic acid as the normal carbonate of soda, its alkaline properties are less marked. We find it in most homes, where they call it carbonate of soda, and use it for cooking. A little of it is often put into the teapot to bring out the colour of the tea, with the idea of making the tea stronger, with doubtful advantage. It is the main ingredient of most baking-powders, as it very easily parts with its carbonic acid, and the gas liberated causes the pastry to rise. Many baking-powders consist of a mixture of bicarbonate of soda and tartaric acid (or acid calcium phosphate), with the addition of some rice-flour. In the course of baking, these two substances react together, forming sodium tartrate, and the whole of the carbonic acid is liberated

The best proportions to take are: 1 lb. of tartaric acid to 1 lb. 2 oz. of bicarbonate of soda. These are the proportions in which they react together according to the equation:

$$\underset{\text{Tartaric acid}}{H_2C_4H_4O_6} + \underset{\text{Sodium bicarbonate}}{2NaHCO_3} = \underset{\text{Sodium tartrate}}{Na_2C_4H_4O_6} + 2H_2O + \underset{\text{Carbon dioxide}}{2CO_2}$$

It is essential that all the materials used should be thoroughly dry. They should be finely powdered and thoroughly mixed. Baking-powder must also be kept in a dry place, as, when wetted, the two substances begin to react with one another. This is seen on throwing a little of the mixture into water, when a violent effervescence takes place. This same principle is made use of in the preparation of effervescing salts, sherbet, fruit salts, saline, seidlitz powders, etc.

There is one other carbonate of soda, the so-called *sesqui carbonate*, which is prepared by mixing solutions of sodium carbonate and bicarbonate. It contains more soda than the crystal soda, and can be used for similar purposes. Its action is somewhat milder, owing to part of the soda being in the form of bicarbonate.

Caustic Soda. The manufacture of caustic soda, either from carbonate of soda by the lime process or by Loewig's process or electrically has already been considered. It is often cast into sticks, and is very readily soluble in water. It exceeds all forms of carbonate or bicarbonate of soda in its powerful scouring or detergent properties in fact, it is too powerful for domestic use, as it attacks and dissolves many substances. A little of the solution between the fingers has an extremely soapy feel, and dissolves the surface of the skin. It is used in large quantities in many industries, particularly in the manufacture of soap and paper, and in the processes for the purification of tar oils and petroleum. The commercial standards of strength for carbonate and caustic soda are somewhat puzzling. Thus, for instance, sodium carbonate 58·5 per cent. will be pure sodium carbonate. Caustic soda of 77·5 per cent. will be pure caustic soda. These figures are got at somewhat as follows.

In both cases for the purposes of reckoning, the percentage of oxide of sodium (Na_2O) in the substance is taken, and as 58·5 per cent. of pure oxide of sodium is theoretically obtainable from pure sodium carbonate, it is said to be 58·5 degrees of strength, or 58·5 per cent.

Ammonia, or Spirits of Hartshorn. By far the most important source of ammonia is the gas liquor which collects in the hydraulic main and scrubbers of the gasworks. But there are, in addition, certain other sources which we shall now enumerate. Ammonia salts are found occurring in a native state thus, ammonium carbonate is found among guano deposits, and also exudes from the surface of the earth in Tuscany, being contained in the so called "suffioni," or volcanic jets of steam, from which it is obtained as a by-product.

As nitrogen, one of the elements which go to make up ammonia, forms four-fifths of the atmosphere, it is only natural that many attempts should be made to convert this nitrogen into ammonia. In spite of the amount of work devoted to this subject, no satisfactory process has as yet been devised for its cheap production on these lines. However, much is hoped for a new process depending on the combination of the nitrogen of the air with calcium carbide. (Frank & Caro.)

Other Sources of Ammonia. Although coal is the chief source of ammonia, it contains but little more than 1 per cent. of nitrogen. It is, however, the main source of ammonia, in spite of the fact that organic waste, such as sewage, contains a much larger proportion. In Paris, the nitrogen of sewage is converted into ammonia compounds and used as manure. The formation of ammonia is brought about by the putrefaction of the sewage. Enormous sums have been wasted in attempts to utilise the ammonia in sewage, which for London alone would amount to 60,000 tons per annum. The road grit, etc., dilutes it so as to make it unsaleable, even after filter pressing for the removal of the water.

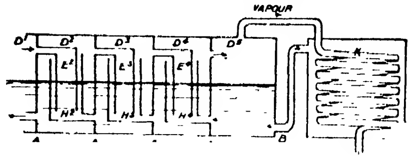
A small quantity of ammonia is also obtained by the distillation of animal refuse, such as bones, wool, leather, etc. The aqueous distillate is treated in the same manner as coal-tar liquor. Not only in the gasworks, but also in other furnaces, such as blast furnaces, gas producers, coke ovens, shale distilleries, etc., where coal is distilled and heated and the product collected, we obtain liquors practically identical with gas liquors from the gasworks, all of which can be similarly treated.

However, by far the greatest quantity of sulphate of ammonia of commerce is obtained from the liquor of the gasworks. More than 200,000 tons per annum is so produced, of which the greater part is exported. This ammonium sulphate is used chiefly as artificial manure [see Manures].

How to Treat Gas Liquor. We shall now consider the working up of gas liquor for the production of ammonia and its salts.

The ammonia is contained in the gas liquor either in the free state or in combination with other substances. For practical purposes, however, it may be regarded as either "free" or "bound." These terms do not apply in the strict chemical sense. The "free" ammonia constitutes the great bulk, and is driven off by merely heating the liquor. The "combined," or "bound" ammonia is driven off only after the addition of lime or other alkali. The volatile ammonia is in combination as carbonate, sulphide, hydrosulphide, cyanide, and possibly acetate. The combined is present as sulphate, sulphite, thiosulphate, thiocarbonate, chloride, sulphocyanide, and ferrocyanide. Before treatment it is usually subjected to an analysis, to determine the proportion of the ammonia that is "free," and whether that proportion which is combined be worth recovery. In many works no attempt is made to recover the combined ammonia, and it is simply run to waste. For many purposes the gas liquor is concentrated. This is carried out in automatically working evaporating plant, which are in use by several firms in this country and abroad.

Solway Still for Concentrating Gas Liquor. A boiler, of which only one end is shown, is divided into partitions at A, and each division thus formed is further subdivided, as shown in section in the diagram [19]. The gas liquor enters at B. We shall imagine the plant in action, when the lower half will be filled with



19. SOLWAY STILL FOR CONCENTRATING GAS LIQUOR

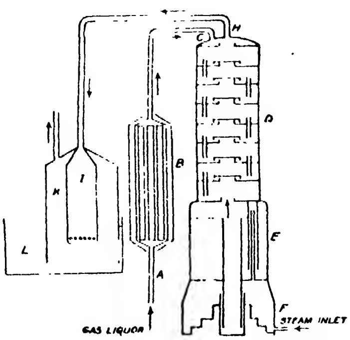
liquor right through. Vapour is given off from the surface of the liquid in each compartment. Take, say, D^5, the vapour passes from here into E^4, and drives some of the liquor from H_4 over into D^4. Thus some of the liquid from D^5 has passed over into D^4. In this way the liquor gradually passes through the boiler in the direction shown by the arrows, leaving the other end of the boiler deprived of its ammonia. The vapour escaping from D^5 is condensed in the worm K, and the heat liberated gives a preliminary heating to the gas liquor as it flows into the boiler. This concentrated liquor serves very well for the manufacture of soda by the ammonia-soda process. It is also used for the manufacture of a solution of pure ammonia gas in water. Formerly, and sometimes even now, the latter is prepared by distilling sulphate of ammonia with lime, but it is more frequently worked up from the gas liquor.

The liquor is distilled and the vapour filtered through wood charcoal, which retains the "empyreumatic" substances which lend to the crude ammonia its peculiar colour and odour. The gas which first comes over should be collected in a separate receptacle, or converted into sulphate. There is a great demand for concentrated ammonia liquor for various purposes.

At the present day the anhydrous liquid ammonia is prepared in some quantity, as it is used for refrigerating machines, the evaporation of liquid ammonia producing a low degree of cold. For the preparation of liquid ammonia, the gas is drawn off from the concentrated liquor by means of a vacuum pump, well dried, and then compressed by another pump into a worm, placed in a cooling tank. The liquid ammonia condenses and collects in a strong wrought-iron cylinder, from which it is drawn off into small cylinders [see Food Preservation].

Sulphate of Ammonia. This is the chief product of the gasworks, and most of the gas liquor is worked up for the production of this substance. Enormous quantities are prepared and exported from this country, particularly for use as fertiliser [see Manures]. The plant employed consists essentially of a still for vaporising the ammonia, and a lead-lined vessel containing sulphuric acid, into which the ammonia gas is conducted. The type of plant will be best understood by reference to the diagram [20]. The still itself is built of two parts. The upper part, or dephlegmating column, is constructed so that the free ammonia is driven off, while steam is retained. As will be seen, it consists of several

compartments, leading into one another through wide openings. The edge of the opening is provided with a ridge, and covered with a cap. The openings are also connected with one another by short lengths of tube. A pool of liquid forms at the bottom of each compartment, held as it were in a tray, and eventually overflows through the narrow tube into the compartment below. This causes the gas passing up through the central openings to bubble through the liquid in the tray under the cap, and thus insures thorough contact of the liquid and the gas.



20. STILL FOR PREPARING AMMONIUM SULPHATE FROM GAS LIQUOR

The gas liquor is heated by steam at B by passing through a series of jacketed tubes before it enters the column at C, and during its descent through the column it is heated by steam entering at F. By the time it has reached the bottom of the column D, all free ammonia will have been driven off. The liquor then runs into the vessel E, into which milk of lime is pumped, and overflows through a wide central tube into the bottom vessel, F, where it trickles over steps and finally escapes. The steam driven in heats the mixture of milk of lime and liquor containing fixed ammonia, so that free ammonia is driven off and passes up the column D. The ammonia escapes at H, and passes into a bell-shaped vessel, I, where, coming into contact with sulphuric acid in the vessel L, it is absorbed with the formation of ammonium sulphate.

Gas liquor always contains some ammonium sulphide and other salts, which are decomposed, forming sulphuretted hydrogen. This and other noxious gases collect in the cover, K, and are drawn off and burnt, or otherwise got rid of. Ammonium sulphate is the salt of ammonia most commonly met with in commerce. It is a white crystalline substance, and the ammonia it contains is easily driven off by heating with lime.

Ammonium Chloride of Sal Ammoniac. This substance was formerly prepared by mixing ammonia with hydrochloric acid, but is now got mostly from the sulphate. A saturated solution of the latter in water is mixed with a strong solution of common salt, and on evaporating somewhat and on the mixture standing, sodium sulphate separates out from the hot liquor, leaving ammonium chloride in solution. Crude ammonium chloride is often discoloured by tar and other impurities derived from the ammonium sulphate from which it is purified by "sublimation." That is to say, the dry solid is heated in iron pots, when it passes into vapour without previously melting. The vapours deposit on the cold surface of covers placed over the pots and form a thick fibrous mass of crystals.

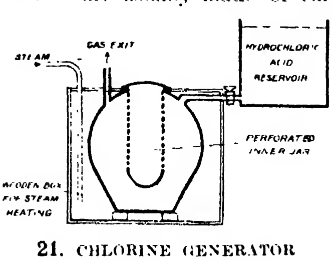
Ammonium Carbonate or Sal Volatile. To obtain this material, familiar to ladies as "smelling salts," ammonium sulphate is mixed with chalk, and the powdered materials heated in retorts, when the carbonate of ammonia sublimes over, leaving sulphate of lime. It forms a white crystalline ice-like mass.

$(NH_4)_2SO_4$ +	$CaCO_3$ =	$(NH_4)_2CO_3$ +	$CaSO_4$
Sulphate of ammonia	Carbonate of calcium or chalk	Carbonate of ammonia or sal volatile	Sulphate of lime

Chlorine. Enormous quantities of chlorine are produced for making chloride of lime, or bleaching powder. Chlorine itself is one of the most powerful bleaching agents known, but is seldom used in the gaseous form for this purpose. Being a gas it is difficult to manipulate; nor is it soluble enough in water to allow of its use in a handy form like a solution of ammonia gas. A weak solution of chlorine in water will often be found on the laboratory bench, but although the bottle is usually pasted over with paper to keep out the light, the solution is mostly decomposed in the course of a few weeks. Chlorine gas compressed into cylinders has been put on the market, but is not yet in general use in this form. As a rule, it is better to convert it into some substance such as bleaching powder, often called "bleach," from which it is easily liberated when required, while, at the same time, it is in a convenient and safe form for transport.

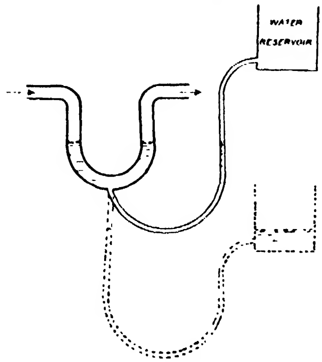
Chlorine itself is a yellow gas which it is difficult to handle, as there are few substances which it does not attack. Its corrosive action is astonishing. The source of most chlorine in commerce is the hydrochloric acid formed in the manufacture of salt cake, and the common method for preparing chlorine is to act on the higher oxide of a metal called *manganese* with the acid. The best material to use is a naturally occurring manganese ore termed "pyrolusite" (MnO_2).

Chlorine Stills. Stills for preparing chlorine are usually made of earthenware [21], as this is found to be more resistant to the action of gas than the commoner metals. The pyrolusite is put into the inner perforated jar. The still is placed in a wooden box for steam heating. Where large quantities are required, vessels made from slabs of sandstone are employed. The pyrolusite is spread on a false bottom,



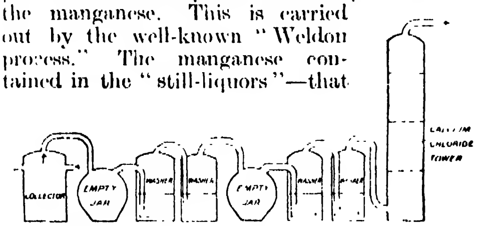
21. CHLORINE GENERATOR

consisting of a perforated plate, and hydrochloric is run in through an earthenware pipe. The gas is let off through another earthenware pipe, and to avoid the use of cocks, which would almost certainly leak, resort is had to an ingenious device [22]. The exit pipe, carrying the gas, is bent in the form of a "U." At the bottom of this is a small hole connected by a flexible tube with a reservoir containing water. By raising this reservoir, the water is led into the bottom of the "U," effectively sealing the pipe. Fig. 23 shows the purification apparatus.



22. DEVICE FOR CUTTING OFF GAS SUPPLY

Manganese Recovery. To work the process economically, it is necessary to recover the manganese. This is carried out by the well-known "Weldon process." The manganese contained in the "still-liquors"—that is to say, the liquors remaining in the still after the chlorine has gone over—contains the manganese in solution as a chloride ($MnCl_2$). The pyrolusite, when acted upon by hydrochloric acid, gives a chloride ($MnCl_4$), which breaks up thus ($MnCl_4 = MnCl_2 + Cl_2$). These two chlorides represent the two salts derived from the oxides of manganese, of which manganic oxide (MnO_2) is the higher and manganous oxide (MnO) the lower. Before the manganese can be used again for liberating chlorine, it must be reconverted into a compound of the higher series. The still-liquors always contain a small quantity of hydrochloric acid remaining over from the excess of acid used, and, after neutralisation with chalk, they are run into a tower or oxidiser, where they are treated with milk of lime, warmed by steam, and acted upon by a current of air. The air converts the manganese into the higher state of oxidation and it is precipitated in combination with a small quantity of lime. This lime does not interfere with the use of the manganese for liberating chlorine from hydrochloric acid, so that it is necessary only to allow the solid matter to settle and run off the clear liquid, which consists largely of calcium chloride. The black slime or mud, commonly called "Weldon mud," which remains at the bottom may be run direct into the stills and treated with more hydrochloric acid.



23. CHLORINE PURIFICATION PLANT

Another Chlorine Process. Chlorine can also be obtained without using manganese. This process, which we owe to Deacon, belongs to that class termed "contact processes," which, as we have already seen, includes one of those processes for making sulphuric acid.

Oxygen of the air is made to combine directly with the hydrogen of the hydrochloric acid to form water, setting chlorine free. The contact substance in this case consists of lumps of coke saturated with chloride of copper. The mixture of air and hydrochloric acid is heated to 400° C. before it reaches the "decomposers," the name given to that part of the apparatus containing the coke and copper salts. This preliminary heating is necessary in order that the reaction may take place, in spite of the fact that heat is given out during the operation as a result of the chemical changes going on. In the manufacture of sulphuric acid by the contact process the same sort of thing happens. When it has been in use for some time the contact substance loses its activity and has to be renewed.

Bleaching Powder. Whichever way the chlorine is prepared, it is usually led direct to the bleaching powder chambers. These are large leaden boxes, as large as dwelling-rooms, in which layers of slaked lime are spread upon floors made of sandstone slabs, and the lime is raked over (*turned*) occasionally to expose fresh surfaces to the action of the gas. The chlorine is absorbed by the lime forming a substance commonly known as "chloride of lime," or bleaching powder. The best lime to use is the purest that can be got. It should fall to a fine powder on slaking, and leave very little residue on a hundred-mesh sieve. Chloride of lime is a very misleading name. We should rightly understand it to mean chloride of calcium or calcium chloride ($CaCl_2$). When "chloride of lime," that is, bleaching powder, is heated with an acid (provided it be not too dilute) chlorine is given off:

$$Ca\left\langle{Cl \atop OCl}\right) + 2HCl = CaCl_2 + H_2O + Cl_2$$

Bleaching powder · Hydrochloric acid · Calcium chloride · Water · Chlorine

The lime of bleaching powder is left behind in combination with the mineral acid used to decompose it. Chlorine in the form of chloride cannot be liberated by treatment with acid, and is useless for the purpose of bleaching. In this form it is termed "fixed" or "bound," while that part of the chlorine which is given off by treatment with acid is termed "available."

Strength of Bleach. A good quality chloride of lime should contain 35 per cent. of available chlorine. Probably the highest strength "bleach" which can be prepared on a commercial scale will not contain over 40 per cent. of available chlorine. In a paper recently published, Davis states that a bleach was prepared (39·76 per cent.) in a plant where a drying

scrubber packed with coke was interposed between the lead chamber and the chlorine stills. Moisture, therefore, interferes with the absorption of the gas, but unfortunately in the case just mentioned the bleach produced was so dry and dusty that the men could not handle it, and the scrubber had eventually to be removed. After its removal, bleach manufactured in the same plant showed a strength of 36 to 37 per cent., and rubbed to putty between the fingers, which is one of the rule of thumb tests for good powder.

The chlorine penetrates with difficulty through the layer of lime spread at the bottom of the chambers. Before turning or raking over, the top layer may contain, say, 36 per cent. bleach, the middle 12 per cent., and the bottom layer perhaps only 2 per cent. These figures are taken from actual experiments recorded by Davis, and they illustrate the importance of "turning" where it is desired to produce a bleach of high strength.

Constitution of Bleach. If bleaching powder yields at the most 40 per cent. available chloride, it is obvious that part of the lime remains unacted upon. Bleach of commerce contains, roughly, two molecules of the hypochloride to one of slaked lime · thus, $2CaOCl_2Ca(OH)_2$, with a small proportion of water. The figures obtained from the high-strength bleach mentioned above as containing 39·76 per cent. available chlorine correspond with the formula $3(CaOCl_2H_2O). Ca(OH)_2$ after allowing for a small quantity of inert matter contained in the original lime. This corresponds to three molecules of the hypochlorite to one of lime. Buxton lime is as good as any for making bleach. It is usual to pass the lime through a sieve before spreading it on the floors of the chambers. Sieved lime usually contains about 71 per cent. of calcium hydroxide available for absorption of the gas; 100 grammes should therefore yield 172 grammes of 40 per cent. bleach, including 6 per cent. of inert matter. As a matter of fact, 180 grammes of 38 per cent. bleach is the usual yield owing to moisture taken up during the operation. High strength bleach usually contains 4 to 15 per cent. of moisture.

Bleaching powder is an almost white powder with a damp appearance and feel. It has a peculiar odour, which is due to the liberation of hypochlorous acid by the carbonic acid from the atmosphere. Hypochlorous acid is a very unstable substance, and readily decomposes, yielding chlorine. This is why strong acids always give chlorine with bleaching powder; if very weak and dilute acids be used, hypochlorous acid is obtained. Salts of hypochlorous acid, such as sodium hypochlorite, are used for bleaching, and are obtained electrolytically.

Chlorates. When chlorine gas is passed into a hot solution of caustic potash or soda the chlorine combines with the alkali to form both chloride and chlorate. The reaction in question may be represented by the chemical equation:

$3Cl_2$	$+ 6KOH$	$= 5KCl$	$+ KClO_3$	$+ 3H_2O$
Chlorine	Caustic potash	Potassium chloride	Potassium chlorate	Water

It will be seen that only one-sixth part of the chlorine is converted into chlorate, five-sixths remaining as the comparatively useless chloride, which would have to be worked up to caustic before it could be used over again.

In the preparation of potassium chlorate it is possible to avoid the formation of potassium chloride by the use of sufficient lime to replace the potash. Milk of lime is run into vessels provided with agitators, and chlorine gas passed in. The chlorine is absorbed with the formation of calcium chloride and calcium chlorate. It is not advantageous to let the temperature get too high. On the other hand, the formation of hypochlorite must be avoided. When the saturation is completed, the liquids are run into "settling" tanks, and the clear liquid carefully tested to see what proportion of calcium chlorate is present. A sufficiency of a solution of potassium chloride is added to react with the calcium chlorate, giving calcium chloride, which remains in solution, and potassium chlorate—a substance soluble with some difficulty, which separates out. On the other hand, although less soluble than calcium chloride, potassium chlorate is by no means an insoluble substance, so that concentration of the liquor is necessary before the crystals begin to separate. In some of the more recent processes lime is replaced by magnesia, and it is claimed that by its use there is less likelihood of loss from chlorate remaining dissolved in the liquor. The crude substance has to be recrystallised to obtain a pure product.

Industrial Uses of Chlorate. Potassium chlorate is largely employed in making matches [see Matches], also for fireworks and some descriptions of explosives, although it is usually found too energetic for the latter purpose. It is also used in calico printing and dyeing, and in medicine. The quantity manufactured is not inconsiderable; several tons are produced annually in this country.

Sodium chlorate is of less importance than the corresponding potassium salt. Like most sodium salts, it is more soluble in water, which makes it better suited for some purposes, as, for instance, in the manufacture of aniline black. It cannot be prepared in the same manner as potassium chlorate, as it is not sufficiently insoluble to be readily separated from the calcium chloride. It is prepared by a modification of the process whereby calcium chlorate is decomposed with sodium sulphate, and calcium sulphate separates out, leaving the sodium chlorate in solution. Chlorates are now prepared electrolytically.

Phosphorus, Phosphoric Acid, and Phosphates. We owe the discovery of this element to the alchemist Brandt. He obtained it in the course of some experiments with urine. The urine was mixed with sand, evaporated to dryness, and strongly ignited. Brandt kept the process secret, and phosphorus remained for a long time even more of a chemical curiosity than radium is to-day.

Urine contains only very small quantities of phosphoric acid, which was the source of the phosphorus obtained, and working a hundred

years later, the Swedish chemist Scheele, finding that bones contained large quantities of phosphates, made use of them for the preparation of phosphorus, and prepared the element in a larger quantity. Bone ash is still the best raw material for making phosphorus, as it consists of very little else but phosphate of calcium, 100 parts of bone ash containing rather over 17 parts of the element. There are other compounds of phosphorus met with in commerce and used not so much for the preparation of the element but in the manufacture of phosphates for manures, as examples of which substances we may mention the minerals apatite (fluoride and phosphate of calcium), phosphorite, etc. We refer to these again in the course on Manures.

Details of the Process. Phosphoric acid is prepared from bone ash by converting the lime into sulphate with sulphuric acid. The operation is carried out in wooden tubs, provided with stirring appliances. The phosphates of lime and water are mixed and then steam is blown in through a lead pipe. The mass is kept stirred while further quantities of sulphuric acid and phosphate are added alternately, until the whole of the charge has been introduced. Enough sulphuric acid must be used to decompose the phosphates, and the reaction will be better understood by glancing at the following equation:

$$Ca_3(PO_4)_2 + 3H_2SO_4 \quad 3CaSO_4 + 2H_3PO_4$$

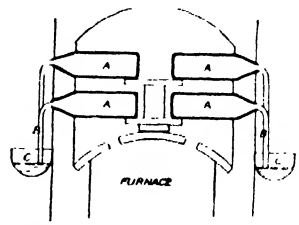
Calcium phosphate or bone ash — Sulphuric acid — Calcium Sulphate — Phosphoric acid.

The phosphoric acid is easily soluble in water, whereas the sulphate of lime is soluble with difficulty. Separation is consequently conducted by filtration. The mass may be filtered through ashes distributed over a layer of clinkers spread in wooden boxes, the clear liquor flowing away through holes in the bottom. Fresh water is added as the liquor drains away, so as to wash out the phosphoric acid. The sludge remaining behind still contains some phosphate of lime with the sulphate, and may be utilised as a manure. The phosphoric acid liquor is concentrated in lead lined tanks. In the course of this operation, small quantities of gypsum (calcium sulphate) contained in the solution are deposited, and the liquor may be run off, leaving the solid impurities behind.

Phosphoric acid prepared in this way contains traces of arsenic. By further concentration, crystals of the acid separate on cooling, which are extremely "deliquescent"—that is to say, they rapidly absorb moisture from the air. This form of phosphoric acid may be regarded as still containing water in combination, and is known as *orthophosphoric* acid (H_3PO_4 equivalent to $HPO_3 + H_2O$). The sodium phosphate of commerce is the disodium phosphate (Na_2HPO_4). If more strongly heated, the orthophosphoric acid loses water, and is converted into *metaphosphoric* acid, a transparent ice-like solid (H_3PO_4 $HPO_3 + H_2O$). It is met with in commerce under the name of the "glacial phosphoric acid." It dissolves in water readily, and is slowly converted into orthophosphoric acid in the cold, but rapidly on boiling.

Manufacture of Phosphorus. To return to the manufacture of phosphorus. The concentrated solution of phosphoric acid, which, as we have explained, is the variety known as orthophosphoric acid, is mixed with roughly ground charcoal, coke or sawdust, and the semi-solid mass dried in a muffle. This forms the raw material ready for distillation.

A series of fireclay retorts are arranged in a furnace with their mouths projecting; a section through a furnace showing four retorts is seen in **24**. The retorts usually used, A, are shaped exactly like short-necked bottles, and are placed horizontally. The material is introduced into the red hot retorts, and a bent iron pipe, B, luted into the mouth of each. The pipe dips into a trough, C, containing water, so that when the retorts are at a bright red heat, and the phosphorus begins to distil over, the vapour passes down the pipes and collects in the trough under the water. The chemical reaction which takes place is brought about by the carbon of the charcoal or coke, which, at the high temperature employed, combines with the oxygen of the phosphoric acid. This latter, by the by, is now in the form of metaphosphoric acid, as water will have been driven off from the orthophosphoric acid in the first stages of the operation. Carbon monoxide and hydrogen gas are given off during the process, so that the troughs are kept covered, and the gases led away and burnt. Some 60 to 70 per cent. of the theoretical yield of phosphorus is obtained.



24. PHOSPHORUS RETORTS IN FURNACE

Purification and Properties. The crude element is discoloured and impure. For the purpose of refining, it is introduced into lead-lined pots, where it is melted under water by means of steam, and treated with a mixture of bichromate of potash and sulphuric acid. The mixture is kept stirred for two hours, at the end of which time the liquid phosphorus should be clear and transparent. When cold the mass is removed, melted under hot water, and moulded into sticks, in which form it comes into commerce.

Phosphorus is extremely inflammable, and must be kept under water. The surface becomes discoloured on keeping, especially if exposed to light, but very little chemical change takes place. It is largely used for making matches [see Matches]. There is another form in which the element occurs known as *red phosphorus*, on account of its colour. This substance, used in the manufacture of safety matches, is obtained on the commercial scale by heating yellow phosphorus in a covered cast-iron pot for some time at a temperature of 240° to 250° C. The cover is fitted with a short tube to act as a safety valve. The hard lumps are ground up with water, and boiled with caustic soda, which dissolves small quantities of unconverted yellow phosphorus.

The two forms of phosphorus differ from one another in a very striking manner. Red phosphorus is not poisonous, or easily inflammable, and is generally inert until strongly heated, when it passes back into the yellow variety.

Alums and Aluminium Sulphate. Strictly speaking, we understand by alums the double salts of certain metals which crystallise with twenty-four molecules of water in the regular system. As a typical example, we may take potash alum, whose composition may be represented by $K_2SO_4 . Al_2(SO_4)_3 . 24H_2O$; that is to say, one molecule each of potassium and aluminium sulphates with twenty-four molecules of water. For technical purposes we need consider only potash, soda, and ammonia alums, although many others have been prepared, some of which do not even contain aluminium, its place being taken by some other metal. As an example we may cite chromium in chrome alum, $K_2SO_4.Cr_2(SO_4)_3.24H_2O$. In most cases where alum is used the sulphate of alumina is the active ingredient, the sulphate of the alkali metal, whether potassium, sodium, or ammonium, being inert.

Sulphate of Alumina Replaces Alum. "At not a very remote date aluminium sulphate was still regarded as merely a laboratory product, and it was only about the year 1845—when Pommier, of Paris, commenced to prepare it on a proper manufacturing scale—that this substance began to be used industrially. Difficulties were encountered at the outset, consumers hesitating to give up the alum to which they were accustomed and which they could rely on obtaining pure in favour of the amorphous, pasty, deliquescent, acid, and often impure product forming the aluminium sulphate manufactured at that date. This distrust was, moreover, heightened in consequence of certain mishaps (due to excessive acidity) that attended the employment of the new product as a mordant and in the sizing of paper; but as soon as a method of producing it in a neutral condition, and free from iron, was devised, aluminium sulphate was promptly adopted and substituted for alum in numerous branches of industry." (Geschwind.)

Nowadays, manufacturers have put on the market pure brands of sulphate of alumina, and this substance has practically replaced the alum previously used for dyeing, papermaking, and other purposes.

"The reason is not far to seek. The various applications of alum are based on its content of alumina, which is barely 10 to 10·6 per cent., whereas aluminium sulphate contains from 14 to 16 per cent. Given equality of price, it is therefore more economical to employ the latter, which, besides being more soluble, is more convenient in use." (Geschwind.)

Although the papermaker no longer buys the double salt, but sulphate of alumina instead, he still calls it "alum," and it is commonly referred to as such.

The "Alumen" of the Ancients. "In ancient times the efflorescence of certain rocks supplied the Greeks, Romans, and Egyptians with a product known by the name of 'alumen,' largely employed in medicine, dyeing, tanning, etc. According to Dioscorides and Pliny, several species of this product were known, some of them perfectly white, others more or less coloured, and all possessing a styptic flavour. They were all more or less complex mixtures of aluminium sulphate and iron sulphate, and the term *alumen* (from which the word alum is derived) had in those days a much wider significance than now." (Geschwind.)

Natural Sources. Natural alums are found in small quantities in a very pure condition, but for its manufacture on a large scale we are dependent on certain products, such as alunite, or alumstone, a natural potash alum found in Italy and Hungary, and alum shale, which was the chief source in this country. These shales vary a good deal in composition, but may be broadly regarded as composed of aluminium silicate, iron pyrites, and bituminous substances. A good deal was obtained from deposits underlying the coal seams in South Lancashire; it was made into heaps (Spence's process) and burnt, the bituminous substances contained in it supplying most of the fuel. After a few days, when the heaps had burnt out, the alumina was extracted from the mass with sulphuric acid. The chief raw materials are, however, the alunite, already mentioned, and bauxite, an impure alumina from which 12,000 to 14,000 tons of aluminium sulphate are now produced annually in France.

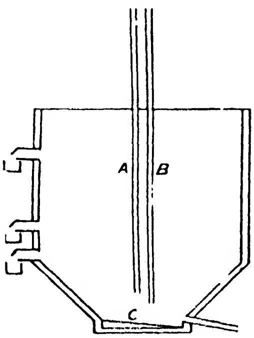
Manufacture from Bauxite. In one process the bauxite is mixed with carbonate of soda and heated in a reverberatory furnace for five hours. On lixiviation, the sodium aluminate is extracted. This operation is carried out systematically so as to heat the fresh melt with weak liquors from the previous one. The liquors are then run into a boiler, provided with an agitator and false bottom, beneath which enter pipes for steam and carbon dioxide gas. In this way the alumina is precipitated as hydroxide, which, on dissolving in sulphuric acid, produces a very high class sulphate.

A modification of this process, originated by Baeyer, considerably reduces the cost in treatment. This method is based on the discovery that when a solution of sodium aluminate is agitated with a small quantity of freshly precipitated aluminium hydroxide the precipitate of alumina goes on increasing, and at the end of a certain time only a small proportion is left in solution.

A More Direct Process. Bauxite, however, contains alumina in a form in which it is directly acted on by acid, so that the manufacture of a crude sulphate on these lines is a comparatively simple matter. The bauxite must be finely ground before heating with acid, otherwise the action of the acid is slow and imperfect. This is effected in France, according to Geschwind, either by means of millstones or edge runners, a sifting contrivance to separate the finely-powdered material from the coarser lumps being usually combined with the latter. An illustration and description of the edge runner

mill will be found in the Paints and Polishes course, and of the millstone under Cement. In these sections also appear descriptions of other grinding plant suitable for treating hard materials such as we are now considering.

The treatment with acid is conducted in wooden vats [25] lined with sheet lead and heated with live steam by a pipe, A. A current of air from pipe B is passed through to keep the mineral in suspension by constant agitation. The base, C, on which the air and steam currents project, is protected with a layer of pumice. The operation takes seven or eight hours, and after allowing to settle, the clear liquor is run off. This first treatment is made with weak liquors from the previous operation, after which the solid residue is subjected to a second treatment, using fresh sulphuric acid. The liquors are concentrated in leaden vats and run out into shallow trays, where they cool and solidify



25. CYLINDRICAL VAT FOR PREPARING SULPHATE OF AMMONIA

Purification. The crude sulphate is often treated to remove the iron, which is the most objectionable impurity it contains. It is possible to remove a great deal from the original bauxite by a preliminary treatment with a weak acid, such as oxalic acid; but, as a rule, the crude sulphate liquors are treated either with potassium ferrocyanide or lead dioxide. In the former case a hot solution of the ferrocyanide (yellow prussiate) is added until no further precipitate of Prussian blue is formed. The clear liquor is decanted, and the blue—which, however, is of inferior quality—can also be utilised. In the second case a paste of lead dioxide is added to the cold liquors when the iron is thrown out in the form of a reddish-brown precipitate (iron plumbate). This second process is not adapted to a sulphate containing free acid, as it would attack and destroy part of the lead peroxide. This is readily recovered for using over again by dissolving out the iron with a carefully adjusted proportion of acid. The other raw material, alunite, which is used on a large scale in the manufacture of alum, has first to be roasted in reverberatory furnaces before attacking with mineral acid. As it contains a quantity of potassium sulphate, it yields by judicious treatment, not only sulphate of alumina, but also potash alum. A ton of alunite will furnish 14 to 16 cwt. of alum and 2 cwt. of sulphate of alumina (15 per cent. Al_2O_3).

Properties and Uses. Sulphate of alumina is a white substance with an acid reaction to litmus, while it turns congo red a purple colour. Potash and the other alkali alums behave similarly. Sulphate of alumina is usually met with as hard lumps difficult to powder and readily soluble in water. A strong solution forms crystals, if given time enough, containing an amount of water approximating to the formula $Al_2(SO_4)_3 18H_2O$. Free acid and iron are the impurities for which the analyst must be on the look-out. The latter is easily detected, even when present in mere traces, by the formation of a blue colour with potassium ferrocyanide. The detection of free acid is a very difficult matter if it be present in small quantities only.

Uses for Alum and Sulphate of Alumina. Both are used as mordants in dyeing cotton, wool, and silk. Aluminium acetate prepared from the sulphate is even preferred. Sulphate of alumina is used largely in the preparation of lake pigments [see Paints and Polishes], for "tawing leather," for precipitating resin size in papermaking, for hardening plaster, slowing the set of cement, and to a large extent for the purification of water and effluents, as so-called *aluminaferric*.

Organic Acids. Under this heading we shall discuss three or four of the more common organic acids, which are used either in industries or for human consumption in such quantities as to necessitate their manufacture on a commercial scale.

Oxalic Acid. This acid is a poisonous substance which is met with in small quantities in such common plants as sorrel and rhubarb.

Pine sawdust, or sawdust from other soft wood, is mixed with caustic alkali and heated. It may, in some cases, be worth while to purify the wood by first extracting the resin. The solution of caustic alkali or alkaline lye is a mixture of caustic soda and caustic potash. The student has learnt that caustic soda and caustic potash resemble one another very closely, and in all ordinary chemical actions they may replace one another. In manufacturing operations, caustic soda is preferred as being cheaper; but the manufacture of oxalic acid is an exception to the general rule, and it makes a great deal of difference whether caustic soda or caustic potash is used for decomposing the wood.

Caustic soda by itself produces little or no oxalic acid, while caustic potash gives the maximum yield. Chemists have, however, found that mixtures of caustic potash and caustic soda in certain proportions (which, of course, will be cheaper than pure caustic potash), may be used instead of the latter substance with equally good results. It is not possible to state here the best proportions to take, as that will depend upon how the process is carried out; some makers use more caustic potash, others more caustic soda.

We may instance one process where three parts of potash are used to two parts of soda and a solution of sp. gr. 1·35 prepared from the mixture. Sawdust and alkaline lye are intimately mixed; one part of sawdust to three parts of solid alkali. The mixture is spread on an iron plate and heated from beneath. A good deal of gas is given off, the mass swelling up. The gases are mostly composed of hydrogen and hydrocarbons. The heating is continued for six hours or so, when a whitish mass remains

behind. The temperature in the furnace is not allowed to rise above 250° C. The mass, which now contains about 20 per cent. of dry anhydrous oxalic acid, is treated with a small quantity of water which dissolves most of the unchanged alkali, leaving the less soluble sodium oxalate behind. This latter is dissolved in water and the solution boiled with lime, when the oxalic acid, in the form of calcium oxalate, a very insoluble substance, remains and can be washed with water. This purified calcium oxalate is decomposed with sulphuric acid in lead-lined vats fitted with "agitators," when a reaction takes place with the formation of calcium sulphate and the liberation of oxalic acid, which remains in solution and is filtered off. Concentration of the solution causes the separation of crystals of oxalic acid in combination with two molecules of water, $C_2H_2O_4 2H_2O$.

Potassium oxalates, known as *salts of sorrel* or *salts of lemon*, are used in photography, as, for instance, in the platinotype process. They are also used for removing ink-stains and iron-mould. Calcium oxalate is the form in which oxalic acid is usually met with in nature. Cerium oxalate is sometimes administered in cases of sickness.

Tartaric Acids. The student who first comes across the tartaric acids is liable to get confused between the different varieties. There are several acids, all of which have the same composition. We may refer to the Pure Chemistry section for an explanation of this riddle. Common tartaric acid, or, correctly speaking, dextro-tartaric acid, is obtained from a deposit forming a crystalline crust at the bottom of the vats in which grape juice ferments. It is, therefore, a by-product in the wine industry. Grapes and most other fruits contain tartaric acid as a potassium salt, and the crystalline deposit, known as *argol*, is also a potassium salt. Argol is, strictly speaking, impure acid potassium tartrate. We have already met with this substance in the form of a precipitate formed on testing for potassium with sodium bitartrate, as it is one of the very few potassium salts which are not readily soluble in water. Argol is recrystallised and gives tartar, and tartar similarly yields cream of tartar. These names, therefore, stand for the same substance in different degrees of purity.

To obtain the acid from the tartar it is added to boiling water to which lime or chalk is added; a dense insoluble precipitate of calcium tartrate settles to the bottom, and requires only to be decomposed with sulphuric acid to yield insoluble calcium sulphate and tartaric acid, which remains in solution. It will be seen that the method by which tartaric acid is prepared from tartar is analogous to the preparation of oxalic acid from crude sodium oxalate.

Tartaric acid may contain traces of lead from the lead vats or from the sulphuric acid, and as it is used largely for human consumption, care should be taken to test for lead, and see that none is there. It is used in conjunction with carbonate of soda for making baking-powder and effervescent drinks. It is also used, like oxalic acid, by the dyer and calico printer.

We have already dealt with acid potassium tartrate, otherwise known as potassium bitartrate, in the form of tartar, cream of tartar, and argol. Like tartaric acid, it is much used for effervescent drinks and also in the dyeing industry. Rochelle salt or potassium sodium tartrate is used medicinally as an aperient. It is formed in the reaction between sodium carbonate and cream of tartar in seidlitz powders.

Citric Acid. This acid occurs naturally in lemon juice and is prepared from lemons on a large scale. Lemons are best used in November, when they contain a maximum amount of the acid. The juice is either expressed from the fruit in Sicily (Sicilian juice), or from fruit imported into England (English juice). The latter is a better class of material, and is more nearly free from other organic acids.

The preparation of pure acid from the juice follows the same lines as the formation of oxalic and tartaric acids. That is to say, calcium salt is first prepared by treating the juice with whiting (calcium carbonate); calcium citrate is precipitated, while malic acid and other impurities remain dissolved. The calcium citrate is decomposed with sulphuric acid, yielding calcium sulphate—which is filtered off—and a solution of citric acid. On concentrating the acid liquors, crystals separate out.

The crystallised acid of commerce contains one molecule of water. It is very soluble, dissolving in about half its weight of water when boiling. It is used for the same purpose as tartaric acid, particularly by calico-printers and in the manufacture of aerated waters. We need not trouble about the salts.

Lactic Acids. These are puzzling substances, related to one another much in the same manner as the tartaric acids, and similarly constituted.

The common acid is formed in small quantities when milk goes sour; but for commercial purposes it is obtained from sugar. The solution of sugar is allowed to ferment, not in the ordinary manner, but under the influence of a curious growth found in stale cheese. In order that this ferment may grow heathily, a little food in the shape of tartaric acid and milk is added. It is a curious fact that the lactic acid, as soon as formed, tends to destroy the activity of the ferment, so that it is necessary to neutralise the acid as fast as it is produced. For this purpose a quantity of chalk is added to the liquid equal to half the weight of the sugar it contains, and in the course of a week or so the whole settles to a semi-solid mass of calcium lactate. Instead of chalk, zinc white (carbonate of zinc) may be used, in which case zinc lactate is formed. Calcium lactate is decomposed with sulphuric acid and the liquor concentrated. It comes into the market in this form, as it is very difficult indeed to get it into a crystalline state. Lactic acid and some of its salts are used for pharmaceutical purposes.

ALKALIS *concluded; followed by* OILS, FATS, AND SOAPS

SADDLERY AND HARNESS

The Various Tools Used in the Manufacture of Saddlery and Harness, and their Purposes

Continued from page 4546

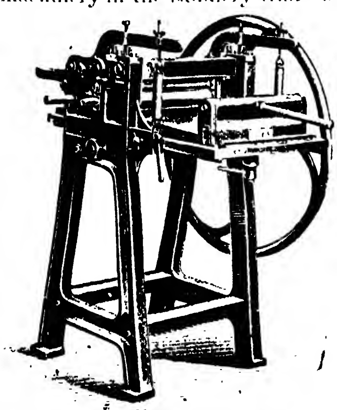
By W. S. MURPHY

THE saddlery and harness-making trade has not yet been absorbed into the factory system. In large centres, such as London, Glasgow, Walsall, and Birmingham, the factory system prevails; but even these factories are not so independent of the craftsman as the weaving factory or the spinning mill. They are rather like big workshops, in which the workmen are well supplied with mechanical tools, set to perform each one a part of the manufacturing process. The greater part of the trade is carried on in workshops employing from three to twenty men, where the goods are mostly made by hand, assisted by machine tools for cutting, and by sewing machines. For that reason we propose to deal with the trade from a craftsman's point of view.

Groups of Tools. Our tools are numerous, and, it looked at in the mass, appear formidable to the learner. For convenience, we shall group the tools and appliances under different heads, as follows: (1) knives and cutting tools; (2) punches and stamping machines; (3) sewing appliances; (4) grippers, holders, and miscellaneous tools.

Knives and Cutting Machines. Adopting the natural principle of proceeding from the simple to the complex, we take up the knives first. The hand knife and the paring knife are constantly in use. The former has a straight, narrow blade, and the latter is broad-bladed, with a straight edge. Shaped like a half-moon, the round knife lends itself to splicing, shaping, and fine work. The head knife has a pointed beak and round head, making it a good tool for cutting holes or round pieces out of leather on the working bench.

Plough Gauge. The first approach to machinery in the saddlery trade was the cutting plough gauge. Before this came into use straps were cut laboriously by use of compasses and knife. The blade of the plough is fixed in a frame which slides along a marked gauge, screws holding the gauge to the breadth required.



1. BELT-SPLICING AND LEATHER-SPLITTING MACHINE

Spokeshave. Next we get the spokeshave, a two-handed tool with a cutting blade in the centre. With this tool any gradation of skive or paring can be cut away.

Splitter. Devised for a similar purpose, but better suited for a large number of straps of the same kind, is the splitting machine [1], which bears some resemblance to a stamping machine.

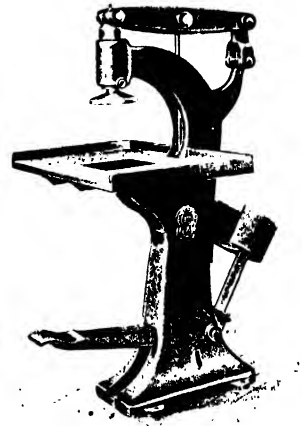
Edge-trimmer. The edge-trimmer is a two-pronged fork, and, as the name implies, is used for trimming edges. Circular pieces are accurately rounded by the washer cutter, which slides on a marked gauge, supported by a centre pin.

Strap-cutter. Midway between knives and stampers are the many cutting machines placed at the service of the trade. Suitable for either the workshop or the factory is the strap cutting machine, with rollers encircled with knives, set to any breadth of strap. On top is a setting wheel, and at the side is the handle, which may be displaced by a driving wheel for power.

Leather-splitting Machine. Similar is the leather-splitting machine [see page 3165], with corrugated feed rollers and straight cutting blade, which reduces to uniform thickness any kind of hide. Splicing or scarfing machines are used to suit all classes of trade, the principle of most of them being a slanted knife, geared to play upon a movable feed, adjustable to any depth of slice.

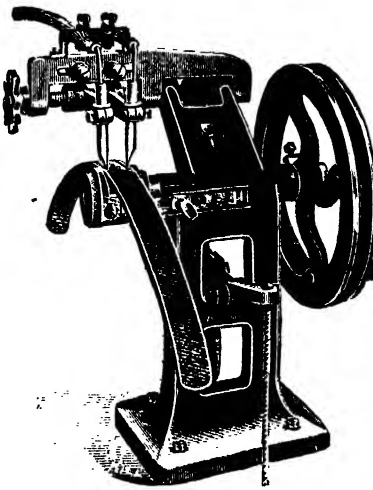
Cutting Presses. Of cutting presses there is a wide variety, ranging from the small fly press [2], closely resembling a die-stamping press, to the huge guillotine presses, that cut saddle-backs, skirts, or horse-collars at a single stroke.

Punches and Stamping Machines. A punching kit comprises a good mallet, a lead punching block, and six each of round and oval striking punches, the sizes ranging from medium small to medium large in both cases. Different in nothing but the kind of mark they make are the scalloping irons, as they



2. FOOT PRESS

are called, with which we please the artistic fancy of the young horseman in shaping for his steed rosettes and scalloped shapes. A hand punch is indispensable and a set of three or four needles to put into it, carrying the size of hole from the smallest striking punch to a pin point.



3. STRAIGHT IRON CREASING VEINING MACHINE

Prickers and Creasers. Pricking irons, some straight, others wheels, like spur rowels, are necessary to mark out the path of the hand stitching. The screw race cuts a channel to hide the stitching. Another curious tool is the curved pin with the beak, which we call the single crease. This is needed as a marker in places where either the compasses or the screw crease cannot go. Screw creases, one light and one heavy, are always provided to mark the lines of stitching on belts, or to make fine lines along the sides.

Checkers and Bevellers. Checkers and bevellers are irons for purposes similar, the latter being used chiefly in a heated state to make ornaments on loops. Compasses, as everybody knows, are two-legged tools used to measure and mark distances, and are therefore equipped with screw and gauge to give accuracy to the work.

Punches. Mechanical punches are in every trade, and need no description ; a nice little one covering the round numbers up to ten, and the oval holes up to twenty-five, is very generally used.

Washer-cutting machines have come into factory use, though they are needed only where a trade with the water-engineer is cultivated. The cutting press is better for our work.

Stitch-pricker. Very useful is the stitch-pricking machine, the mechanically-driven spindle taking on prickwheels of any size, and running above a holder which curves or straightens the work as required, marking the stitches for the needle with an accuracy no hand could equal.

Creasing Machines. Simple as it appears when done by the hand, creasing work presented serious difficulties to the mechanical inventor. Lately, however, several good creasing machines have come on the market [3 and 4]. The belt or flap to be creased is run through a guide by a corrugated roller, while the creasing irons, hot or cold, are held in the adjustable arm above.

Sewing Appliances. The saddler uses awls like the shoemaker, and needles like the tailor, but with variations which can best be understood in the actual working. The seat awls are square-bladed and straight-pointed ; stitching awls are curved ; and sewing awls are round and straight. Our needles have curved blades hollowed up to the middle, with wide eyes. Before beginning to stitch, the saddler or harness-maker arms his palm with an iron protector, called the hand-iron, honeycombed so as to grip the needle head. These protectors save the hand and at the same time add to the purchase of the sewer's thrust on the needle.

Sewing Machines. While the sewing-machine makers were looking around for more worlds to conquer, it was inevitable that the saddlery and harness-making trade should receive attention. At first the sewing machine was decisively relegated to the lightest work, the severe strains to be borne by most belts and traces being quite under-estimated by the makers. Of late years we have been able to welcome a number of machines which produce work equal in strength to the best hand work. Saddles and other parts of the horse's equipment cannot be made by mechanical means, but belts, bridles, bands, and traces are now made in the factory by sewing machines.

Miscellaneous Tools. Pincers, nippers, and pliers are needed for pulling out nails, stretching the leather over points, and other purposes. To hold the seam while being hand-sewn we have the clamps, jaws of bent wood, held together at the bottom by a straight block, and forming a curved jaw at the top. The tool is old and finely conceived.

WHEEL CREASING OR VEINING MACHINE

Stuffing Rods. These are required for filling evenly the saddle pads and collars. Some are merely sticks with a nick in the end ; others are bent steel rods, like large awls. With these the flock, horse-hair, or straw is put into the various pads.

Loop sticks, burnishers, loop-forming machines and dies, trimming and burnishing machines, with hammers and mallets, complete the outfit.

Continued

Continued from page 4570

THE CLARIONET

Registers and Pitch. Intervals. Fingering. Effects. Exercises. Basset Horn. Bass and Double-bass Clarionet

By ALGERNON ROSE

TO-DAY there are two leading types of clarionets—those made in France with a straight bore, and those in Germany with thicker wood and conical bore. The former speak with greater facility, whilst the latter possess a rounder tone, especially in the lower register. But, between the mellow tone best suited for the concert-room and the more brilliant effects required when leading a long column upon the march there is a golden mean in the average type which the student should endeavour to acquire. Clarionets possess either 6, 9, 11, 13, or 15 keys. That most used is the ordinary 13-keyed instrument. According to the system of manufacture, whether English or French, and whether with German or real silver keys, so the price ranges from £2 to £15 15s. The reeds cost from 1s. 4d. to 5s. per dozen. When ordering, it should be stated whether hard, medium, or soft quality is required. A case for the instrument of American cloth, swan-lined, can be obtained from 5s. upwards.

The Parts. In a full military band, as in certain modern scores of Strauss and Wagner, the clarionet family consists of the following instruments: First, the smallest, or E♭, which has often an important melody part; secondly, the B♭, or principal instrument of the military band. This is written for usually in three parts, the first being termed the "solo," the second and third, "ripieno," or, literally, "filling up" harmony parts. In an orchestra, the B♭ player sometimes uses clarionets in A and C. In military bands, in addition to the E♭ and B♭, instruments in D, F, and A♭ are occasionally employed. All these, excepting the one in C, are called "transposing" instruments, because they do not sound the actual note written. Thirdly, there is the alto clarionet, which acts as a connecting link between the B♭ clarionet and the bassoons. Lastly, we have the bass clarionet, and the monster double-bass. But no matter how many keys or levers an instrument has, or the pitch to which it is tuned, each member of this musical family is made up of three parts: the lower joint (for the right hand), the middle joint (for the left hand), and the bulbous upper joint, superimposed by the mouthpiece in which the reed is fixed.

The Reed. Upon the substance of the reed the quality of the tone in a great measure depends. This slip of yellowish-white sugar-cane should be prepared and adjusted with the greatest care, so that it may be perfectly straight, and neither too hard nor soft. Otherwise it is apt to whistle and squawk. Nowadays, however, the beginner has a great advantage over the tyro of a generation ago, who had to prepare his own reeds, because such requisites can be obtained ready finished and cheap from any military instrument seller. But the best reed in the world will not ensure a good effect if the keys do not act properly, in which case probably the pads need fresh lining—not a difficult operation. Remove the pad and cut out a new one. Hold the key over a light until the lacquer melts. Press on the fresh lining. Replace the key, squeezing the new substance tightly over the hole while the key is still warm.

In the Army it is usual for a young beginner to start with the E♭ clarionet, because that instrument, having the shortest tube, has the holes closer together. The keys, therefore, are easier to manipulate for small fingers. If a boy fifer shows exceptional musical ability he is generally put on to an E♭ clarionet or a soprano cornet, to which his lips are more suited than the larger varieties of those instruments. But, so far as arrangement of the keys (or pistons) is concerned, the fingering is precisely the same on the larger models. Therefore, the student, no matter what length of tube he takes up, will find the instruction given for any one of them adaptable to any other.

Attitude. As this is a military instrument, the student must assume a soldierly attitude. Stand upright and throw out the chest. Rest the clarionet on the right thumb. Do not bend the knees. Turn out the feet, and keep the heels slightly apart. The angle at which the instrument is inclined forward from the body is indicated correctly when the elbows are pressed under the ribs. Place the underlip over the teeth. Rest the reed on the lip. Blow down the instrument without touching the keys.

Tone Production. The open sound produced without manipulation of the keys gives the note written as G, second line treble clef. As there are several varieties of clarionets, it does not follow that the G sounded corresponds with the G on the piano. The student

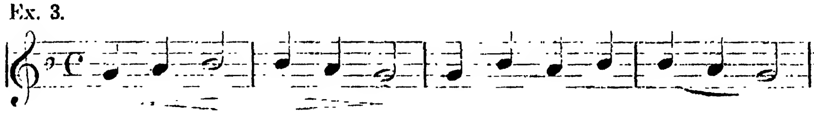
Ex. 1.

who has a musical ear will naturally be puzzled to know why he should be taught that a sound representing some other note should be called G. Before he argues that the musical system of transposing instruments is wrong, he should remember that, even as nations are ruled by expediences, so have military instrument players found it desirable to sacrifice calling the notes by their correct names for the sake of being able to finger every instrument in the clarionet family in a uniform manner. Thus, no matter how long or how short is the tube employed, it has been found far easier to adopt a compromise, so that the music played makes the same impression on the eye, although the effect is different to the ear.

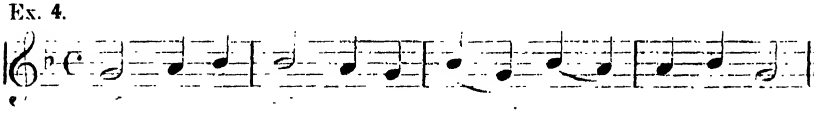
The reason why an orchestral clarionet player works with two, and sometimes three, instruments is because certain series of sounds are easier to play on an A than on a B♭ or a C, owing to the acoustical divisions of each tube producing the natural harmonics peculiar to them. So the C clarionet is, generally speaking, best suited for the natural key, the B♭ clarionet for flat keys, and the A clarionet for sharp keys. The longest of these is the A. It is so called because when it plays the note C, written on the third space treble clef, the actual sound produced is A below.

Ex. 2.

Ex. 3.



Ex. 4.



The instrument of medium length is called B♭ because when C is played the actual sound produced is B♭. The shortest of the trio alone gives the actual C as it is written. At one time all clarionets were pitched in C, but the better quality of tone produced by lengthening the tube led to composers employing the latter, and transposing the parts in the score so as to save the bandsman being confused in any way. Because of the less satisfactory timbre of the C, this instrument is to-day least used of all members of the family, save by amateurs who like to try over solos with piano accompaniment. To get the utmost brilliancy, military instrument makers, by considerably shortening the column of air of the C tube, produced the smallest instrument, E♭. This is so called because when the C, third space treble clef, is played the sound actually produced is the E♭ above. Thus, the E♭ instrument sounds a minor third higher than the notes written in the band parts, whilst at the same time the A clarionet may be sounding the same written notes a minor third lower than they appear to the eye. The mechanism being the same on all four instruments, the question is, Which is the easiest to begin with? A young lad in the Army, as noted, is generally put to the E♭; but a man is recommended to begin with the A clarionet, because the greater length of its tube renders easier the production of the tone throughout the compass. Try Ex. 1, keeping strict time.

The Embouchûre. Much depends, in good clarionet playing, on what is called the "embouchûre"—the mouthpiece of the instrument. The latter being continually between the lips and teeth of the player, the word has come to denote the arrangement of the lips, tongue, and so forth, in the production of tone. It is important to note that blowing out the cheeks does not augment the force of the sounds. The ancient Roman trumpeters used to bind the faces of their pupils to prevent this, and Alcibiades considered that, in flute playing, it detracted from the charm of the music. Take every opportunity to watch and get hints from good clarionet players in military bands. There is no reason why the charm of the tone should be destroyed by facial contortion. Do not bite the mouthpiece with the teeth. Hold it by a gentle pressure of both lips, so that the reed may vibrate freely. If the mouthpiece is compressed too tightly, the reed has not free play, the tone produced is poor, and the lips soon become fatigued. To produce the sound required, the tongue sends the necessary air into the instrument by a short, sharp stroke. This forces a sufficient quantity of breath into the tube to make the requisite sounds. Once the musical vibration is produced, it must be sustained without increasing or diminishing the force of the blowing.

As regards tone-quality, what is wanted is a combination of sweetness and brilliancy in effect. The student should strive to get a soft and full sound before increasing its power or intensity. Try to avoid a harsh and screaming quality. When once a harsh tone has become habitual, the player is seldom able to get anything else. Rather than force the tone of the reed unnecessarily, some players twist round the mouthpiece and play with the reed uppermost. But, for practice and for solo work, it is better to play with the reed on the lower lip, as the tone is then softer and more agreeable.

The Registers. Although the intensity of the sound is affected by the degree of the force of breath, the pitch of each note is influenced in the same manner, for it will be found that, when sustaining a low note, if it is blown beyond

a certain point the tone will jump off and elicit quite another sound. This brings us to the consideration in the clarionet of what players call the "registers." Berlioz and Prout divide these into *four* : the low, or grave ; the Chalumeau, or medium ; the acute ; and the high, ranging respectively from E below third ledger line, to E, first line ; F, first space, to B♭ above ; B♮ to C, second ledger line above ; and D to D, on the sixth ledger line. But certain German players divide the tone into *three* registers. The first they call the Chalumeau, giving the notes deepest in pitch. This extends from E below third ledger line under treble staff, to B♭ on the third line. The second register, or medium, produced by greater pressure on the reed, extends from B, third line treble clef, to D♭ over second ledger line above treble staff.

Finally, the highest register, known as the Upper, and least satisfactory on account of its shrieking qualities when indifferently played, extends from C♯ on second ledger line above treble staff, to C over fifth ledger line, nearly an octave above.

2nd and 3rd Sounds. Having mastered Ex. 1, proceed to get the tone above the G. Control the lower joint of the instrument by the right hand, as described, and the middle joint by the left hand. With the first left finger, open the A key. In touching it, the forefinger reaches the key by a slight turn. As the wood has been hollowed out to receive the key, the latter has not far to go. Manipulation, therefore, should be done delicately. The touch of the fingers should always be light and almost soft. There is no necessity to raise any finger high when playing. After getting the A clearly and practising it like the G, combine it with the latter note, as in Ex. 2.

Further behind the instrument, to the top, will be found the B♭ key. Place down on this the left thumb. This will produce the semitone above A. If he wishes to check the correctness of his sounds at a piano keyboard, he must remember, if using an A clarionet, that every note in the music should be read on the piano a minor third lower. Thus, with all the fingers off, the actual sound is E. With the A key pressed down, the real tone is F♯. Now that the B♭ key is brought into requisition, the result is G. Try these three notes in succession, till they are produced correctly and in good time, without hurrying [Ex. 3]. This study in G minor should be played smoothly. Do not leave any perceptible gaps between successive sounds, especially where the notes are connected by a slur. Do not sound the notes in the first two bars spasmodically, but let the intensity of the breath form a true crescendo and diminuendo, keeping strict time. The exercise may be repeated in a different way [Ex. 4].

Here special emphasis is given to the first notes in the opening bar. But the student can write out the same notes entirely as minims, and get a crescendo on each note, beginning softly and increasing the tone gradually. The crescendo is easier than the decrescendo. For the latter, begin with the full tone, then diminish the breath gradually, counting mentally two very slow beats for each sound.

Pitch. Unless the clarionet is used daily it will be found to vary considerably in pitch. This is only natural, because a wooden tube, after being made damp and not touched for a few days, will contract in its fibres as it gradually dries. Then the sudden moisture of the breath will cause it to swell rapidly, so that the internal diameter of the instrument is lessened, and the pitch of the sounds produced consequently raised. Some players, when a clarionet has been laid aside for a while, will take off the keys a day or two before performance and steep the tube in grease. This, of course, is an exceptional expedient. More reliable as a way to insure the correctness of the pitch is unremitting daily practice. Nevertheless, the student must not feel discouraged if, when attempting to play with a piano accompaniment, he finds that, before the piece has concluded, although he started in tune, his instrument has gone up nearly a semitone. A good player, under such circumstances, can, by slackening the pressure of his lip on the reed, humour the latter so as to lower the pitch ; or he can, by tightening the pressure, raise it. But any such strain involves giving undue attention to pitch to the neglect of producing the best quality of tone and performing the music in the most accurate manner. In other words, the proper place of the clarionet is in a band rather than in the home circle, and, when practising with an instrument of fixed pitch, like the piano, a great deal of valuable time is often wasted in trying to adapt it to the accompaniment.

When a clarionet is provided with a tuning slide the tone can be lowered by extending the upper joint of the mouthpiece. But if this is done to any extent it upsets the accuracy of intonation between the different intervals when playing. But accuracy of intonation should be cultivated from the beginning with the greatest care, for the clarionet has certain exceedingly beautiful tone-qualities distinct from those of other musical instruments, and the student whose intonation is of an indifferent character can never hope to excel. Some people cannot work successfully alone. The best method for such students to adopt is to persuade a friend to begin to learn the instrument at the same time. Much enjoyment will be obtained by practising together easy studies and tunes arranged for two clarionets. These pieces can be obtained from any military music-seller. The difference in pitch will then not be noticed, as the change will be alike in both instruments.

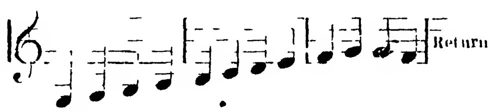
The Low Tones. The student has already learnt how to produce G, A, and B♭, the G being the open note, the A being produced by opening the A key with the left forefinger, and the B♭ by opening that key with the left thumb. To get the F below the G, take the left forefinger off the A. With that finger cover the hole below. With the second finger open the F key at its side, or, with the first right finger, the F key on the upper joint by the A

trill. The note produced will then be F, first space treble clef. Next raise the first left finger. The sound will be F♯. Cover the first hole of the upper joint with the first left finger. E, first line, treble clef, will result. Place the second finger on the second hole; the sound will be D below the first line treble clef. With the third finger, open the key by its side; the sound will be D sharp. Cover the third and last hole on the upper joint with the third finger; the semitone C, first ledger line, will result. The fourth finger should then open the key behind the third hole; this will give C♯. Keeping the left fingers down, place the first right finger on the first hole of the lower joint; B, below the C, will be produced. Put the second finger on the second hole, and A will result.

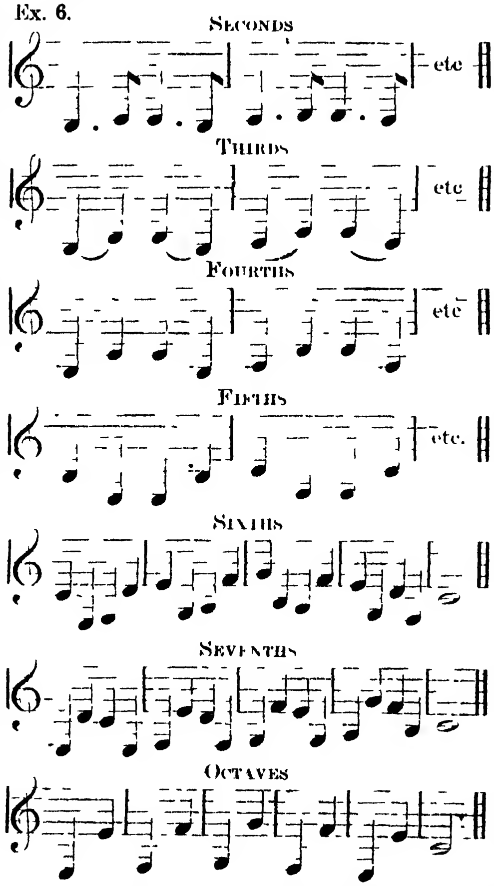
Open the key at its side with the third finger; this will sound A♯. Release that key and put the third finger on the third hole, and the sound will be G. With the fourth finger, open the large key behind the third hole; G♯ will result. Release that key, and let the fourth finger cover the hole to the right; the result will be bottom F. Let the left fourth finger now open the smaller of the two long keys in the upper joint; this will raise the bottom F a semitone. Lastly, let the fourth finger cover the hole below the largest key; this will produce the deep E, the lowest sound of the instrument. So the student will now understand how to get the various tones and half-tones from the open G to the lowest sound in the bottom register.

Beginning with this note, the deep E, the student should now go up the scale in whole tones, disregarding the keys away from the line of the holes. Blow each sound as firmly as possible. Keep strict time. Preserve the force of the breath after the tongue has started the notes, so that the sound is maintained fully as long as each note lasts. This exercise, which should be taken very slowly, will strengthen the muscles of the mouth. Avoid distending the cheeks, and take care not to let the breath escape from the sides of the lips. [Ex. 5.]

Ex. 5



Ex. 6.



Intervals. It is important not only to practise the scale given, very slowly up and down the lowest register of the instrument, but to endeavour to obtain a crescendo, and then a decrescendo, on each note before proceeding to the next. Equally necessary, if progress is to be made, is the study of intervals. First try seconds; then thirds, skipping each intervening note; fourths, skipping two notes; fifths, skipping three; sixths, skipping four; sevenths, skipping five; and octaves. This will train the eye as well as the ear, so that, later on, no matter what intervals occur, they may be played with precision. Not only should the right notes be sounded, but it is excellent training to play them alternately staccato and legato. Then, as the student masters the initial difficulties, he can gradually increase the pace at which he plays each exercise. [Ex. 6.]

The student may consider this rather uninteresting work. But it has to be mastered sooner or later; therefore, the sooner the better.

As the clarionet is a military instrument, a point to observe is time. If a note is produced badly, no matter; complete the phrase. Then go over the exercise again until the note wanted is sounded correctly and in proper time. It should be remembered that, later on, when playing on the march, it will not be possible, if a mistake is made, to get the column to halt while the phrase is repeated. For the staccato effect sound each note smartly with the tongue. Then cut off the sound suddenly by holding the breath.

The Second Register. Having tried various exercises in the lowest octave, proceed to the register above. This, ascending from the B on the third line, is somewhat difficult for beginners. The B is fingered like the lowest E. Sound that again; then increase the pressure of the lips. The result will be not an octave, but a twelfth higher. This is owing to the difference in the bore of the instrument being unlike that of the flute or oboe. Bind

this B with the A preceding it. Note that the B♭ key at the back of the instrument must always be left open for the second register.

The student will now have to learn to ascend the scale of C major, beginning at B on the third line, and going up to F over third ledger line above staff, or twelve notes from the B. When this is mastered, the student will be able to play twenty-three notes without accidentals from the lowest E up the compass of the instrument and down again.

Fingering. It is well here to recapitulate certain points hitherto partially explained. If all the key mechanism is taken off, it will be found that, in a thirteen-keyed clarionet, there are twenty side-holes. Now, seven of these holes are closed by the left thumb and the first, second, and third fingers of the right and left hands; two more are closed by the little fingers pressing the open-standing keys; one hole is stopped by either, or both, of the right second and third fingers acting on the rings. The remaining holes are manipulated by closed keys. Arrange the fingers so that all the holes are closed. Then raise them successively. Blow softly. The notes given will be A, B, C, D, E and F. Next, sound the G from the thumb-hole. The two lower keys, we know, when closed, produce the low F and E. A matter we have not hitherto mentioned is that the B♭ key, negotiated by the left thumb, is called the *Speaker*, so-called because, when the hole is covered and the low note is blown harder, the tone "speaks" a twelfth higher. Thus, G sounds, not G above, as it would do on the flute; but the D over the G. A does not give A octave, as it would on the oboe, but E over the A. B produces F; and so on. This charming peculiarity of the clarionet distinguishes it from other wood or reed instruments.

Another speciality of the clarionet is that its low register gives what are called "chalumeau" sounds, the tone being reminiscent of the "schalmey," the clarionet's antitype. This obsolete instrument was played by a single reed cut in the mouthpiece of the cane-tube itself, so that it could not be removed. To the eye of the beginner the complications of the modern key-mechanism may, at first, seem bewildering, for its actual simplicity requires some explanation before it is perceived. Then, instead of feeling bewildered, the student marvels at the ingenuity which enables the player to overcome with ease much that not long ago was impossible. For it must be obvious that, if the instrument is pierced by no fewer than twenty side-holes, and the player has only two thumbs and eight other fingers, means must be provided for keeping ten out of the twenty holes automatically closed. It must also be evident that, to negotiate twenty holes with ten digits, each finger must be employed in various ways. Through the inventions of Albert and Boehm, the primitive clumsiness has been improved in a remarkable manner. By means of the chart on the next page the student should be able to learn the names of all the holes and keys, and the way in which the clarionet is fingered from one end of its compass to the other. There are seven holes and thirteen keys, covering as many more—or twenty holes altogether. The keys are numbered successively from the bell. Each key, as well as each hole, has two names, designating the low and higher registers, the latter being a twelfth above the former. Begin with the key nearest to the bell. This is known as No. 1, and is called the E, or B key. No. 2 is the F♯, or C♯ key. No. 3, higher up to the right, is the F, or C key. No. 4, also to the right, is the E♭ or A♭.

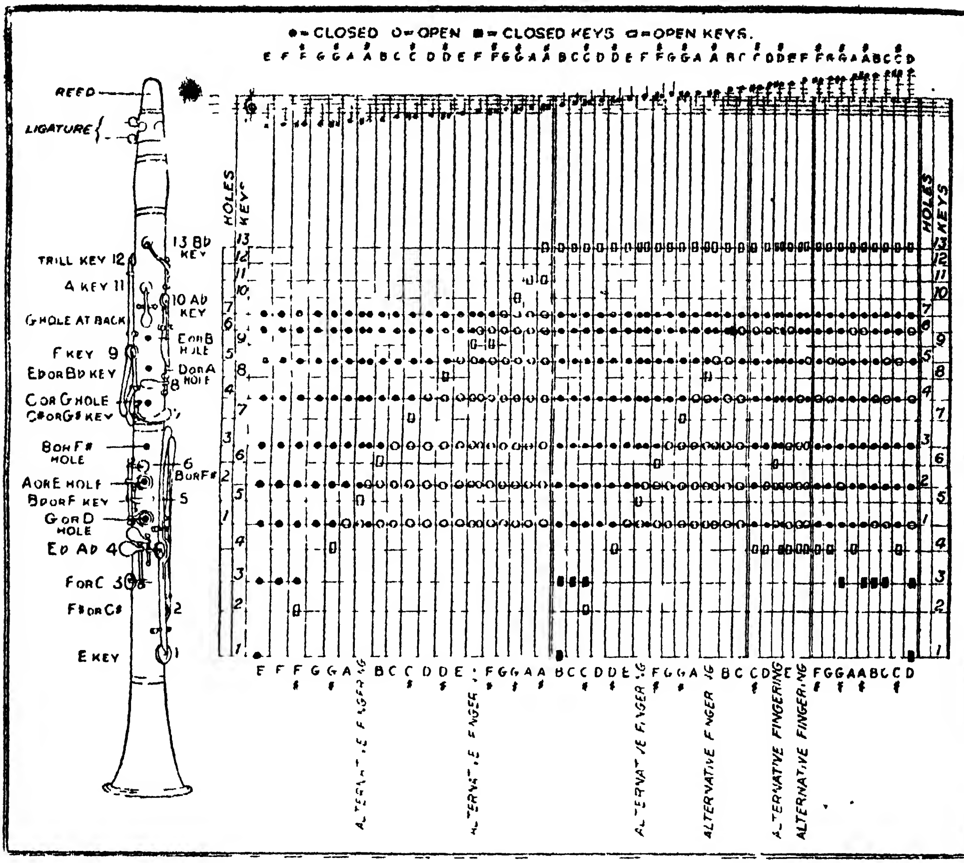
Then comes the G, or D hole. In other words, when this hole, as well as those above it, is covered, the note sounded is the low G below second ledger line, treble clef; or, if the instrument is blown with more force, the D on the fourth line on the staff above. The fifth key is called the B♭, or F above. Then comes the second hole, for A or E. The sixth key, round to the left, is known as the B, or F♯. Above that is the third hole, also giving B or F♯. That completes the lower joint of the instrument negotiated by the right hand. The seventh key, manipulated by the left hand, gives C♯ or G♯. Then comes the fourth hole, producing C or G. Above that is the eighth key, giving E♭ or B♭. Next comes the fifth hole, which sounds the D or A. Then we have the ninth key for F. Above that is the sixth hole, called E or B. Next, we have the seventh, or G, hole. Above that is the tenth key, known as A♭. The eleventh key gives A; the twelfth is the Trill key; and lastly, the thirteenth is the B♭ key. Attention to the table appended will show what fingers should be used for the manipulation of each note. Certain sounds, like the low A♯, F on the first space, the octave F above, and the A♯ above that, have alternative fingerings, of considerable advantage in certain passages.

The Shake. The *shake* is one of the most beautiful effects obtainable from the clarionet. But it must be executed evenly. Begin slowly, and increase the speed gradually. If a trill is performed unevenly it loses its charm.

Ex. 7.

Ex. 8.

According to the key, the shake is made either a tone or a semitone higher than the note



indicated. Begin with the note written, and alternate it with the sound above, resolving the shake by two grace notes before concluding it [Ex. 7].

The student should try this exercise on almost every note of the scale. He should not be discouraged if first attempts are unsuccessful. The player, if his ear is good, will by-and-by discover ways of getting the effects in the neatest manner. The most difficult shakes, which must not be attempted at first, are shown in Ex. 8.

BASSET HORN

The basset horn is the alto clarionet in F, known also as the "corno di bassetto." In appearance it is somewhat more imposing than the clarionets described, as its top and bottom shanks are of metal, the mouthpiece, tube, and the bell being curved. The basset horn is useful in a military band as a connecting link between the second and third B♭ clarionets and bassoons. Passages which are too high for the bassoon, or inconveniently low for the B♭ clarionet, can be played with ease on this instrument. Generally, the alto clarionet plays harmony notes but it frequently relieves the bassoon in its higher passages. Combined with the euphonium, it serves to soften the melody. The instructions given as to the fingering and the blowing of the B♭, A, and other clarionets apply to this instrument, as its mechanism is almost the same. The main difference is that the alto clarionet in F sounds every note a fifth below the clarionet in C. But the timbre is different, and for this reason exceedingly valuable to composers. Both Mozart, in his "Requiem," and Mendelssohn, in his "Funeral March," have parts for two basset horns together. But, although in those compositions the character of tone is gloomy, Beethoven made serviceable use of this instrument in his ballet music of "Prometheus."

The alto clarionet is a beautiful instrument. Its tone is powerful from the lowest E, below third ledger line, to the E above. It is less good from that E to the B♭ on the third line. But the quality from the B♭ to the D, over second ledger line above treble clef, is excellent. Higher than that, the tone is uncertain, and of little use.

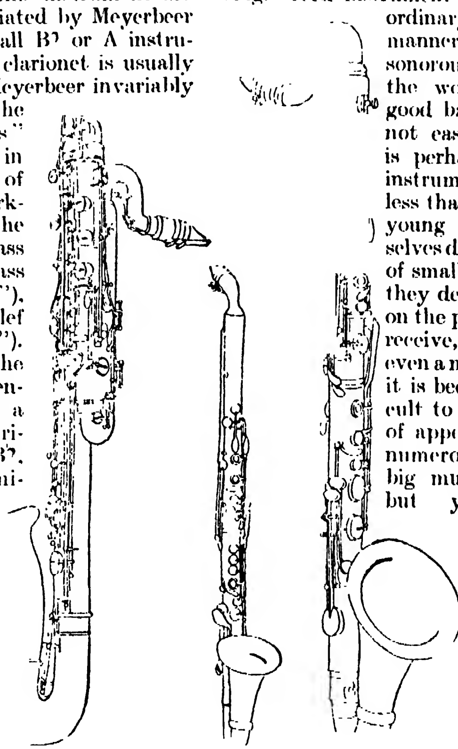
BASS CLARIONET

The bass clarionet is in A, B♭, or C. It speaks an octave lower than its smaller brethren lettered in the same way. To economise space, the large instrument has a turned-up metal bell. Its mouthpiece shank is also of metal, and curved considerably downwards towards the player. As regards the fingering, the mechanism resembles in construction that of the ordinary clarionets

described. On account of the greater length of tube, however, the holes are further apart, and give space for more auxiliary keys; so the finger stretches are not only greater, and the instrument not only heavier, but some bass clarionets have as many as twenty-one keys, only two holes being acted upon directly by the fingers of the player [see illustration].

The bass clarionet, unless required for special solos, is played in a military band with the first or second bassoon. In small bands, one bass clarionet and one bassoon suffice. When well played, the lower notes of this instrument are superb—a fact much appreciated by Meyerbeer and Wagner. Like the small B♭ or A instruments, the part of the bass clarionet is usually written in the treble clef. Meyerbeer invariably adhered to this plan, and in the fifth act of the "Huguenots" he displays the telling tones in the extreme low compass of this instrument in a remarkable manner. Wagner, on the other hand, wrote for the bass clarionet sometimes in the bass clef (as in the "Walküre"), and sometimes in the tenor clef (as in "Tristan and Isolde"). Charts are procurable of the fingerings, throughout the entire compass of three and a half octaves, for the bass clarionet—whether tuned in A, B♭, or C—showing how every semitone is produced on an instrument provided with twenty-one keys. The student, who should be prepared to play in other clefs, should first transpose this staff into the bass, starting from the E♭ on the first ledger line below the staff.

In this instrument the 14th key is F; the 15th, F♯; the 16th, G; 17th, G♯ (or A♭); 18th, A; 19th, an auxiliary B♭; 20th, the B shake key; and the 21st, the B♭ octave key.



DOUBLE-BASS CLARIONET (Besson & Co) — TENOR CLARIONET — BASS CLARIONET (Rudall Carte & Co.)

The bass clarionet, although unsuitable for solo playing except on rare occasions, is most useful in strengthening the reed department of a military band, and helping to keep the bassoons in tune. On this instrument long sustained notes have a grand effect. But tonguing is difficult, and many of the shakes are almost impossible. The bass clarionet, therefore, does not demand great digital execution. Rather must the student cultivate the production of a good tone-quality and the faculty of playing in strict time, because if the deep bass clarionet, with its powerful sound, attacks a chord too soon or too late, it will completely spoil the effect, and throw out the smaller clarionets.

In a full military score the part of the bass clarionet is immediately below the basset horn and over the bassoon. Above the former come the various saxophones, and over these the B♭ clarionet, oboe, E♭ clarionet, and the flutes. The bass clarionet has been found by Wagner, Strauss, Tschaikowski and others, of considerable value as a means of infusing into the modern orchestra an unusual tint of tone-colour. The bass clarionet extends the peculiar tone-qualities of the single reed instrument an octave lower than its ordinary compass in a beautiful manner, adding a delightful sonorousness to masses of the wood-wind. Nevertheless, good bass clarionet players are not easy to find. One reason is perhaps the expense, such an instrument, new, costing not less than £10 10s. Hundreds of young men will devote themselves diligently to the usual type of smaller instrument, and, when they depend for their livelihood on the private engagements they receive, find it difficult to earn even a modest income. Moreover, it is becoming increasingly difficult to make a limited number of appointments suffice for the numerous candidates, when the big music schools are turning out yearly many finished clarionet players. It is well for the ambitious student, therefore, to give attention to such special instruments as the bass clarionet. By doing so he distinguishes himself immediately from the rank and file of players, and is in a position to demand and receive better terms.

At the Brussels Conservatoire is one of the earliest attempts existing of a bass clarionet, the bore coiling five times on itself, serpentine fashion.

THE DOUBLE-BASS CLARIONET

We give here, to complete the clarionet family, an illustration of the BB♭, used at the Royal Military School of Music, Kneller Hall. By doubling the tube, its increased length enables it to sustain contra-bass pedal notes with magnificent effect. The cost of this (£48) is rather beyond the individual, but is within the means of large societies. So far as the fingering is concerned, it will be readily understood by the student who has familiarised himself with the bass clarionet mechanism.

CLARIONET *concluded*

ITALIAN—FRENCH—SPANISH—ESPERANTO

Italian by F. de Feo; French by Louis A. Barbe, B.A.; Spanish by Amalia de Alberti and H. S. Duncan; Esperanto by Harald Clegg

ITALIAN

Continued from page 4640

By Francesco de Feo

IRREGULAR VERBS

Second Conjugation

Verbs in **ere** (short)—continued

(*Past Def.* in *si*. *Past Part.* in *so* or *sto*.)

Accendere, to light

Past Def.—*Accesi, accese, accèsero.*
Past Part.—*Acceso.*

Accludere, to enclose

Past Def.—*Acclusi, accluse, acclùsero.*
Past Part.—*Accluso.*
Conjugate like *acclùdere*: *conclùdere*, to conclude; *esclùdere*, to exclude; *inclùdere*, to include; *preclùdere*, to hinder.

Alludere, to allude

Past Def.—*Allusi, alluse, allùsero.*
Past Part.—*Alluso.*
Conjugate like *allùdere*: *delùdere*, to delude; *illùdere*, to illude.

Appendere, to hang up

Past Def.—*Appesi, appese, appèsero.*
Past Part.—*Appeso.*

Ardere, to burn

Past Def.—*Arsi, arse, àrsero.*
Past Part.—*Arso.*

Chiedere, to ask

Ind. Pres.—*Chiedo* (*chieggo*), etc.; *chièdono* (*chièggono*).
Past Def.—*Chiesi, chiese, chièsero.*
Subj. Pres.—*Chieda* (*chiegga*), etc.
Past Part.—*Chiesto.*
Conjugate like *chièdere*: *richièdere*, to request.

Chiudere, to shut

Past Def.—*Chiusi, chiuse, chiùsero.*
Past Part.—*Chiuso.*
Conjugate like *chiùdere*: *conchiùdere*, to conclude; *dischiùdere*, to open, to disclose.

Concedere, to grant

Past Def.—*Concessi, concedei, concedetti; concesse, concedè, concedette; concèssero* and *concedèttero.*
Past Part.—*Concesso* (*conceduto*).
Conjugate like *concèdere*: *succèdere*, to succeed; *recèdere*, to recede.

Decidere, to decide

Past Def.—*Decisi, decise, decìsero.*
Past Part.—*Deciso.*
Conjugate like *decìdere*: *recìdere*, to cut off.

Difendere, to defend

Past Def.—*Difesi, difese, difèsero.*
Past Part.—*Difeso.*
Conjugate like *difèndere*: *offèndere*, to offend.

Dipendere, to depend

Past Def.—*Dipesi, dipese, dipèsero.*
Past Part.—*Dipeso.*

Dividere, to divide

Past Def.—*Divisi, divise, divìsero,*
Past Part.—*Diviso.*

Eludere, to elude

Past Def.—*Elusi, eludei, eludetti; eluse, eludè, eludette; elùsero,* and *eludèttero.*
Past Part.—*Eluso.*

Esplodere, to explode

Past Def.—*Esplosi, esplose, esplòsero.*
Past Part.—*Esploso.*

Evadere, to evade

Past Def.—*Evasi, evase, evàsero.*
Past Part.—*Evaso.*

Fondere, to melt

Past Def.—*Fusi, fuse, fùsero.*
Past Part.—*Fuso.*
Conjugate like *fòndere*: *confòndere*, to confound; *diffòndere*, to diffuse; *effòndere*, to pour out; *infòndere*, to infuse.

Incidere, to engrave

Past Def.—*Incisi, incise, incìsero.*
Past Part.—*Inciso.*
Conjugate like *incìdere*: *coincìdere*, to coincide

Remarks on Irregular Verbs

1. The greater part of the verbs in *-ere* end in past definite in *-si* (first person singular), *-se* (third person singular), and *-sero* (third person plural). As has been already seen, the other persons are regular, thus:

Accèndere (to light). *Past def.*: *accesi, accendesti, accese, accendemmo, accendeste, accèsero.*
Chiùdere (to shut). *Past def.*: *chiusi, chiudesti, chiuse, chiudemmo, chiudeste, chiùsero.*
Decìdere (to decide). *Past def.*: *decisi, decidesti,* etc.

2. The past participle of these verbs is nearly always irregular, and is formed by the addition of the terminations *-so*, *-to*, or *-sto*, thus:

Ridere (to laugh). *Past part.*: *riso.* *Lèggere* (to read). *Past part.*: *letto.* *Chièdere* (to ask). *Past part.*: *chiesto.*

3. The verbs with the stem ending in *d, n, nd*, lose these letters before the *s* of the terminations *si, se, sero*, of the past definite, and the terminations *so, sto* of the past participle. Thus:

Ardere (to burn), *arsi*, I burned; *arso*, burned.
Rimanère (to remain), *rimasi*, I remained; *rimasto*, remained.
Spèndere (to spend), *spesi*, I spent; *speso*, spent.

4. A few verbs change the vowel of the stem. Example: *fòndere* (to melt)—*Past Def.: fusi*; *Past Part.: fuso.*

EXERCISE XLIII.

1. Vedete se hanno acceso i lumi nella sala da pranzo. 2. Che cosa avete concluso? 3. Essi speràvano di ottenère chi sa che, ma son restati delusi (*disappointed*). 4. Gli scioperanti àrsero una gran quantità di grano. 5. Egli mi chiese del danaro, ma non gliene diedi. 6. Chiudete le finestre, perchè si avvicina un gran temporale. 7. Oggi è festa, e tutte le botteghe sono chiuse. 8. Tutti còrrono verso la chiesa; chi sa cosa sarà successo. 9. Essi decìsero di partir sùbito, senza aspettare il vostro avviso. 10. Si è offesa perchè non le abbiamo restituito la vìsita. 11. L'Italia era divisa in tanti pìccoli stati. 12. Il prigioniero (*prisoner*) eluse la vigilanza delle guàrdie e riuscì a fuggire. 13. Si confùsero le lingue.

ESERCÌZIO DI LETTURA

Nei tumulti[1] popolari c' è sempre un certo nùmero d'uòmini che, o per un riscaldamento di passione, o per una persuasione fanàtica, o per un disegno scellerato, o per un maledetto gusto del soqquadro,[2] fanno di tutto per ispinger le cose al pèggio; propòngono o promòvono i più spietati[3] consigli, sòffian nel fuoco ogni volta che principia a illanguidire: non è mai troppo per costoro; non vorrèbbero che il tumulto avesse nè fine nè misura. Ma per contrappeso,[4] c' è sempre anche un certo nùmero d'altri uòmini che, con pari ardore e con insistenza pari, s'adòprano[5] per prodùr l'effetto contràrio; taluni mossi da amicìzia o da parzialità per le persone minacciate; altri senza altro impulso[6] che d'un pio e spontàneo orrore del sangue e dei fatti atroci. Il cielo li benedica. In ciascuna di queste due parti opposte, anche quando non ci siano concerti antecedenti, l'uniformità dei voleri crea un concerto istantàneo nelle operazioni. Chi forma poi la massa, e quasi il materiale del tumulto, è un miscùglio accidentale d'uòmini, che, più o meno, per gradazioni indefinite, tèngono dell'uno o dell'altro estremo: un po' riscaldati, un po' furbi, un po' inclinati a una certa giustizia, come l'intendon loro, un po' vogliosi[7] di vederne qualcuna grossa,[8] pronti alla feròcia e alla misericòrdia, a detestare e ad adorare, secondo che si presenti l'occasione di provàr con pienezza l'uno o l'altro sentimento; àvidi ogni momento di sapère, di crèdere qualche cosa grossa, bisognosi di gridare, d'applaudire a qualcheduno, o d'urlargli dietro.[9] (Manzoni, "I Promessi Sposi," Cap. XIII). *Continued.*

NOTES. 1, tumults; 2, confusion; 3, inhuman; 4, to counterbalance; 5, endeavour; 6, impulse; 7, eager; 8, something striking; 9, to howl after him.

Idiomatic Expressions

The student should become familiar with the following expressions, which are of daily use:

Avèr la gentilezza di, to be so kind as
Èsser finito, to be over
Lo spettàcolo è finito, the performance is over
Mi si dice, I am told
Mi è stato detto, I have been told
Avèr notìzie di, to hear from
Non ho notìzie di lui, I haven't heard from him
Farei mèglio, I had better
Fareste molto mèglio, you had much better
A che serve? what is the use?
Secondo me, in my opinion
Secondo lui, according to him
Èsser di cattivo umore, to be in a bad temper
Servirsi, to help one's self
Si serva, help yourself
Avére da, to have to, to be obliged to

EXERCISE XLIV.

1. Abbia la gentilezza di dirmi come si dice questo in Inglese. 2. Quando arrivammo in chiesa il servìzio era già finito. 3. Invece di star qui a far niente, fareste molto mèglio a studiare la vostra lezione d'Italiano. 4. Avete notìzie del signor Carlo? 5. No, non abbiamo più notìzie di lui; forse non è a Londra. 6. Lasciàtemi in pace, vi prego; son di cattivo umore oggi, senza saperne il perchè. 7. Se le càpita di vedère (*if you happen to see*) il suo amico, àbbia la gentilezza di dirgli di venire da me stasera, perchè ho da parlargli. 8. Mi dispiace di non potere accompagnarla; ho da scrìvere delle lèttere importantissime. 9. Secondo me, in primavera ricominceranno le ostilità. 10. A che sèrvono questi ferri? 11. Si serva, signore; come vede tutto è pronto. 12. A che serve ritornare sul passato? Quel ch' è fatto è fatto.

CONVERSAZIONE

Chi ha chiuso la porta?
L' ho chiusa io.
Chi ha acceso il lume nella mia càmera? Lei, non è vero?
Io no; era già acceso quando sono entrato.
Che giornali ha comprato?
Ho comprato il *Corriere della Sera* e il *Mattino.* Quale vuole?
L'uno o l'altro; fa lo stesso.
Non ho più notìzie di suo nipote; dov' è?
E chi lo sa; è un anno che non ci scriviamo più.
Di chi sono queste carte?
Sono mie, gràzie.
Mi è stato detto che la signora N. è di nuovo a Firenze, sarà vero?
Secondo me dev' èsser vero, perchè l'altro giorno m' è parso di vedére la sua cameriera.
Dio buono, che donna!

KEY TO EXERCISE XL.

1. Where did you know that gentleman? 2. I knew him at Nice last year. 3. I acknowledge my mistake, and I beg your pardon. 4. My esteem for the young sailor increased much when I heard him praised in such a way by his captain. 5. One knows where one was born, but one does not know where one dies. 6. He was born of very poor parents, but by constant work he has succeeded in putting together a fair fortune. 7. They have insisted so much that I have ended by yielding. 8. At the end of the

dinner, all drank to the health of the married couple. 9. The thieves broke the glass of a window on the ground floor, and penetrated into the house. 10. To-day I was present at a terrible scene; a poor mason fell and broke his leg.

KEY TO EXERCISE XLI.

1. The house of which I have spoken to you is in Via Roma. 2. He who cannot obey does not know either how to command. 3. Do what I have told you, and you will prosper. 4. We must love him who loves us, but we must not hate him who hates us. 5. I thank you for the many proofs of friendship that you have always shown me. 6. Let me see what you have in your pocket. 7. I have returned him the money that he lent me. 8. The lady whom you have seen is our landlord's wife. 9. The order that you gave me has been faithfully executed. 10. That is all I know; I cannot tell you more. 11. The aged husbandman plants the seed of the tree, whose fruits his sons and grandchildren will see.

KEY TO EXERCISE XLII.

1. How much have you paid for this hat? 2. Whose pocket-book is this? 3. Who has brought this luggage? 4. That gentleman is an Englishman, is he not? 5. Which is the train for Rome? 6. What have you ordered for Christmas? 7. What is the matter with these boys? 8. Who is that (man)? 9. At which station shall we stop? 10. To whom have you given the ticket? 11. What has your father said? 12. Of which lady are you talking? 13. In what year were you born? 14. Of what is your cousin thinking? 15. Who has asked to be admitted?

Continued

FRENCH

Continued from page 4651

By Louis A. Barbé, B.A.

IRREGULAR VERBS
Third Conjugation

1. **S'asseoir,** to sit down, *s'asseyant, s'étant assis.*

Ind. Pres.—je m'assieds, tu t'assieds, il s'assied, nous nous asseyons, vous vous asseyez, ils s'asseyent.

Imperf.—je m'asseyais.

Past Def.—je m'assis.

Future.—je m'assiérai.

Cond. Pres.—je m'assiérais.

Subj. Pres.—que je m'asseye, que tu t'asseyes, qu'il s'asseye, que nous nous asseyions, que vous vous asseyiez, qu'ils s'asseyent.

Imperf.—que je m'assisse.

Imperat. (positive).—*assieds-toi, qu'il s'asseye, asseyons-nous, asseyez-vous, qu'ils s'asseyent.*

Imperat. (negative).—*ne t'assieds pas, qu'il ne s'asseye pas, ne nous asseyons pas, ne vous asseyez pas, qu'ils ne s'asseyent pas.*

There is a transitive form *asseoir,* to seat. The alternative conjugation, *je m'assois, je m'assoyais, je m'assoira,* etc., is seldom used.

2. **Mouvoir** to move, *mouvant, mû,* f. *mue.*

Ind. Pres.—Je meus, tu meus, il meut, nous mouvons, vous mouvez, ils meuvent.

Imperf.—je mouvais.

Past Def.—je mus.

Future.—je mouvrai.

Condit. Pres.—je mouvrais.

Subj. Pres.—que je meuve, que tu meuves, qu'il meuve, que nous mouvions, que vous mouviez, qu'ils meuvent.

Imperf.—que je musse.

The derivatives *émouvoir,* to move, to affect; *s'émouvoir,* to be affected, and *promouvoir,* to promote, take no circumflex accent in the past participle: *ému, promu.*

3. **Pouvoir,** to be able, *pouvant, pu.*

Ind. Pres.—je peux, or *je puis, tu peux, il peut, nous pouvons, vous pouvez, ils peuvent.*

Imperf.—je pouvais.

Past Def.—je pus.

Future.—je pourrai.

Cond. Pres.—je pourrais.

Subj. Pres.—que je puisse, que tu puisses, qu'il puisse, que nous puissions, que vous puissiez, qu'ils puissent.

Imperf.—que je pusse.

Of the two forms of the first person singular, present indicative, *puis* is the only one that can be used interrogatively: *Puis-je?* May I? Can I?

In the Future and the Conditional the two *r's* are not pronounced separately.

Pouvoir is used absolutely with the meaning of "to be able to do": *Je ne puis rien pour lui,* I can do nothing for him.

The Subjunctive followed by its subject is used to express a wish. In that case the first person singular takes an acute accent: *Puissé-je réussir, puissiez-vous réussir,* May I succeed, may you succeed, etc.

4. **Savoir,** to know, *sachant, su.*

Ind. Pres.—je sais, tu sais, il sait, nous savons, vous savez, ils savent.

Imperf.—je savais.

Past Def.—je sus.

Future.—je saurai.

Cond. Pres.—je saurais.

Subj. Pres.—que je sache, que tu saches, qu'il sache, que nous sachions, que vous sachiez, qu'ils sachent.

Imperf.—que je susse.

Imperat.—sache, qu'il sache, sachons, sachez, qu'ils sachent.

Savoir and *connaître* both mean "to know." *Connaître* means "to know" in the sense of "to be acquainted with," and therefore applies to persons and places: *Je connais son frère,* I know his brother; *Il connaît Paris,* He knows Paris. *Savoir* means "to know" as the result of study: *il sait sa leçon.*

Savoir is also used when the object is a fact or statement, or a pronoun referring to a fact or statement: *Savez-vous ce que je viens*

d'apprendre? Do you know what I have just learned? *S'il était venu, je le saurais,* If he had come, I should know it.

Savoir also means "to know how to," and therefore to be able: *Cet enfant sait déjà lire et écrire,* That child can read and write already.

Savoir is frequently used negatively without *pas* or *point*: *Je ne sais ce que je dois faire,* I do not know what I should do.

5. **Valoir,** to be worth, *valant, valu.*

Ind. Pres.—je vaux, tu vaux, il vaut, nous valons, vous valez, ils valent.

Imperf.—je valais.

Past Def.—je valus.

Future.—je vaudrai.

Cond. Pres.—je vaudrais.

Subj. Pres.—que je vaille, que tu vailles, qu'il vaille, que nous valions, que vous valiez, qu'ils vaillent.

Imperf.—que je valusse.

Equivaloir, "to be equivalent," and *revaloir,* "to repay," are conjugated like *valoir. Prévaloir,* "to prevail," differs from it in the Present Subjunctive: *Que je prévale, que tu prévales, qu'il prévale, que nous prévalions, que vous prévaliez, qu'ils prévalent.*

6. **Voir,** to see, *voyant, vu.*

Ind. Pres.—je vois, tu vois, il voit, nous voyons, vous voyez, ils voient.

Imperf.—je voyais.

Past Def.—je vis.

Future.—je verrai.

Cond. Pres.—je verrais.

Subj. Pres.—que je voie, que tu voies, qu'il voie, que nous voyions, que vous voyiez, qu'ils voient.

Imperf.—que je visse.

In the Future and the Conditional the two *r*'s are not pronounced separately.

7. **Vouloir,** to wish, want, to be willing, *voulant, voulu.*

Ind. Pres.—je veux, tu veux, il veut, nous voulons, vous voulez, ils veulent.

Imperf.—je voulais.

Past Def.—je voulus.

Future.—je voudrai.

Cond. Pres.—je voudrais.

Subj. Pres.—que je veuille, que tu veuilles, qu'il veuille, que nous voulions, que vous vouliez, qu'ils veuillent.

Imperf.—que je voulusse.

The *Imperative* is hardly ever used, except in the form *veuillez,* or *veuillez bien,* "please," "have the kindness."

Bien added to *vouloir,* gives the idea of consent: *Venez-vous avec nous? Je veux bien,* Are you coming with us? I am quite willing.

En vouloir à, means "to have a grudge against," "to have designs on."

Il m'en veut d'avoir agi sans le consulter, He bears me a grudge for having acted without consulting him.

Vouloir dire, literally, "to wish to say," is the usual expression for "to mean," "to signify"; *Que veut dire ce mot?* What is the meaning of that word?

Fourth Conjugation

1. **Boire,** to drink, *buvant, bu.*

Ind. Pres.—je bois, tu bois, il boit, nous buvons, vous buvez, ils boivent.

Imperf.—je buvais.

Past Def.—je bus.

Future.—je boirai.

Cond. Pres.—je boirais.

Subj. Pres.—que je boive, que tu boives, qu'il boive, que nous buvions, que vous buviez, qu'ils boivent.

Imperf.—que je busse.

2. **Dire,** to say, to tell, *disant, dit.*

Ind. Pres.—je dis, tu dis, il dit, nous disons, vous dites, ils disent.

Imperf.—je disais.

Past Def.—je dis.

Future.—je dirai.

Cond. Pres.—je dirais.

Subj. Pres.—que je dise, que tu dises, qu'il dise, que nous disions, que vous disiez, qu'ils disent.

Imperf.—que je disse.

With the exception of *redire,* to say again, which, like *dire,* has *vous redites* in the Present Indicative, and *redites* in the Imperative, all the derivatives have *-disez* in the second person plural. They are: *dédire,* to retract, gainsay; *contredire,* to contradict; *interdire,* to forbid; *médire,* to backbite; *prédire,* to foretell (*vous prédisez, vous contredisez,* etc).

3. **Faire,** to make, to do, *faisant, fait.*

Ind. Pres.—je fais, tu fais, il fait, nous faisons, vous faites, ils font.

Imperf.—je faisais.

Past Def.—je fis.

Future.—je ferai.

Cond. Pres. je ferais.

Subj. Pres.—que je fasse, que tu fasses, qu'il fasse, que nous fassions, que vous fassiez, qu'ils fassent.

Imperf.—que je fisse.

Faire, followed by an infinitive, means "to cause to be," "to get," "to have." *Il fait bâtir une maison,* He is getting a house built; *Je ferai relier mes livres,* I shall get my books bound.

In this construction, if the second verb has a direct object, the object of *faire* is indirect: *Je le fais lire,* I make him read; but *Je lui fais lire un livre français,* I make him read a French book.

Faire, followed by an adjective used as a noun, means "to play the part of," "to pretend to be." *Il fait le sourd,* He pretends to be deaf.

Nouns are occasionally used in this construction: "*L'homme n'est ni ange, ni bête; et le malheur veut que qui veut faire l'ange fait la bête,*" Man is neither an angel nor a fool; but ill luck will have it that he who wants to play the angel makes a fool of himself.

EXERCISE XXXIV.

1. Little Mary, seated in an arm-chair (*le fauteuil*), was reading the story of Little Red Riding-Hood (*le Petit Chaperon Rouge*).

2. When the poor girl had done her work, she used to go (and) sit down in the ashes (*la cendre*); that is why she was called Cinderella (*Cendrillon*).

3. Do not sit on the grass; it is damp; you would catch cold (*s'enrhumer*).
4. He spoke every moment (at each instant) of going away, but he always sat down again (*se rasseoir*), and we could not get rid (*se débarrasser*) of him.
5. To (*pour*) move his hearers (*auditeur*) the orator must himself be moved; one does not move without being moved.
6. An army is a body animated (*animer*) by (*de*) an infinite number (*une infinité*) of different passions which a skilful (*habile*) man sets in motion (*faire mouvoir*) for the defence of the fatherland (*la patrie*).
7. When we (*on*) cannot do what we wish, we must try to wish what we can.
8. We speak little when vanity does not make us speak.
9. We easily forget our faults when they are known only to (*de*) ourselves.
10. Perfect valour is to do without witnesses (*le témoin*) what we should be capable of doing before everybody.
11. Weak people (*la personne*) cannot be sincere.
12. We are nearer loving those who hate us than those who love us more than we (*ne*) wish.
13. A philosopher has said that few people (*gens*) know how to be old.
14. Vanity makes us do more things contrary (*contre*) to our taste than (does) reason.
15. What we know is little in comparison with (*de*) what we do not know: and sometimes, even what we do not know is just what we ought to know.
16. To know that one knows nothing (it) is to know a great deal.
17. The man who sells himself is always paid more than he (*ne*) is worth.
18. Great thoughts come from the heart.
19. The proverb tells us that everything comes in due time (*à point*) to (him) who knows how to wait (*attendre*).
20. We speak well (*dire du bien*) of our friends for two reasons: first of all (*d'abord*) that (*pour que*) they may learn that we speak well of them, and then (*ensuite*), that they may speak well of us.
21. What a judicious (*judicieux*) foresight (*la prévoyance*) was not able to put into the minds (*l'esprit*) of men, a more imperious mistress (*impérieux*), I mean experience, has forced them to believe (it).
22. Tell us what we must do, and we shall do it immediately.

Key to Exercise XXXIII.

1. Le Petit Chaperon Rouge partit pour aller chez sa grand'mere, qui demeurait dans un autre village.
2. Le loup qu'elle rencontra lui demanda où elle allait.
3. La petite fille lui dit: "Je vais voir ma grand'mere et lui porter une galette avec un petit pot de beurre que ma mère lui envoie."
4. Le loup se mit à courir de toute sa force par le chemin qui était le plus court, et la petite fille s'en alla par le chemin le plus long, s'amusant à cueillir des noisettes et à courir après des papillons.
5. Le Chat Botté dit à l'Ogre: "On m'a assuré que vous aviez le pouvoir de vous changer en un rat et une souris; je vous avoue que je tiens cela tout à fait impossible."—"Impossible," reprit l'Ogre: "vous allez voir."
6. Il ne tiendra qu'à vous, Monsieur le Marquis," dit le Roi, "que vous ne soyez mon gendre."
7. Le Chat devint grand seigneur, et ne courut plus après les souris que pour se divertir.
8. La fée dit à Cendrillon: "Va dans le jardin: tu y trouveras six lézards derrière l'arrosoir; apporte-les-moi."
9. "Je te recommande surtout de ne pas passer minuit: si tu demeures au bal un moment de plus, ton carrosse redeviendra citrouille, tes chevaux des souris, tes laquais des lézards, et tes vieux habits reprendront leur première forme."
10. La vieille fée dit que la princesse se percerait la main d'un fuseau, et qu'elle en mourrait.
11. La princesse se percera la main, mais elle n'en mourra pas; au lieu d'en mourrir, elle tombera dans un profond sommeil qui durera cent ans, au bout desquels le fils d'un roi viendra la réveiller.
12. Le Petit Poucet alla se recoucher et ne dormit point du reste de la nuit: il se leva de bon matin, et alla au bord d'un ruisseau, où il emplit ses poches de petis cailloux blancs, et ensuite revint à la

Continued

SPANISH

By Amalia de Alberti & H. S. Duncan

UNCLASSIFIABLE IRREGULAR VERBS—continued

Third Conjugation

Asir, to seize, grasp, *asiendo, asido.*

Ind. Pres.—asgo, ases, ase, asimos, asis, asen.

Imperat.—ase, asga, asgamos, asid, asgan.

Subj. Pres.—asga, asgas, asga, asgamos, asgais, asgan.

The other tenses are all regular.

Conducir, to lead, to conduct, *conduciendo, conducido.*

Ind. Pres.—conduzco, conduces, conduce, conducimos, conducis, conducen.

Past Def.—conduje, condujiste, condujo, condujimos, condujisteis, condujeron.

Imperat.—conduce, conduzca, conduzcamos, conducid, conduzcan.

Subj. Pres.—conduzca, conduzcas, conduzca, conduzcamos, conduzcais, conduzcan.

Subj. Imperf.—condujéra, condujeras, condujera, condujeramos, condujerais, condujeran, or *condujese,* etc.

Subj. Fut.—condujère, condujeres, condujere, condujeremos, condujereis, condujuren.

The Future of the Indicative and the Conditional are regular.

Decir, to say, to tell, *diciendo, dicho.*

Ind. Pres.—digo, dices, dice, decimos, decis, dicen.

Past Def. dije, dijiste, dijo, dijimos, dijisteis, dijeron.

Imperat. di, diga, digamos, decid, digan.

Subj. Pres.—diga, digas, diga, digamos, digais, digan.

Subj. Imperf.—dijera, dijeras, dijera, dijeramos, dijerais, dijeran or *dijese,* etc.

Subj. Fut.—dijere, dijeres, dijere, dijeremos, dijereis, dijeren.

The Imperfect of the Indicative is regular, the Future and the Conditional have the regular endings applied to the stem *dir.* Example: *diré,* etc., *diría,* etc.

All the derivatives of *decir,* as *contradecir* (contradict), *desdecir* (to give the lie to), etc., are conjugated in the same manner as *decir,* save that the second person singular of the Imperative is generally *dice* instead of *di.* Example: *contradice. Bendecir,* to bless, and *maldecir,* to curse, are regular in the Imperfect and Future of the Indicative, in the Conditional, and in the second person singular

and plural of the Imperative; in all other tenses these verbs follow the conjugation of *decir*.

Ir, to go, *yendo, ido.*
Ind. Pres.—voy, vas, va, vamos, vais, van.
Imperf.—iba, ibas, iba, ibamos, ibais, iban.
Past Def.—fui, fuíste, fué, fuimos, fuisteis, fueron.
Imperat.—ve, vaya, vamos, id, vayan.
Subj. Pres.—vaya, vayas, vaya, vayamos, vayais, vayan.
Subj. Imperf.—fuera, fueras, fuera, fuéramos, fuérais, fueran or *fuese*, etc.
Subj. Fut.—fuere, fueres, fuere, fuéremos, fuéreis, fuéren.
The Future of the Indicative and the Conditional are regular.
The reflexive verb *irse*, to go away, is conjugated in the same way as *ir*.
Ind. Pres.—me voy, te vas, se va, nos vamos, os vais, se van.

Oir, to hear, *oyendo, oido.*
Ind. Pres.—oigo, oyes, oye, oimos, ois, oyen.
Past Def.—oí, oiste, oyó, oimos, oisteis, oyeron.
Imperat.—oye, oiga, oigamos, oid, oigan.
Subj. Pres.—oiga, oigas, oiga, oigamos, oigais, oigan.
Subj. Imp.—oyera, oyeras, oyera, oyéramos, oyérais, oyeran or *oyese*, etc.
Subj. Fut.—oyere, oyeres, oyere, oyéremos, oyéreis, oyeren.
The Imperfect and Future of the Indicative and the Conditional are regular.

Salir, to go out, *saliendo, salido.*
Ind. Pres.—salgo, sales, sale, salimos, salis, salen.
Fut.—saldré, saldrás, saldrá, saldrémos, saldréis, saldrán.
Cond.—saldria, saldrias, saldria, saldríamos, saldríais, saldrían.
Imperat.—sal, salga, salgamos, salid, salgan.
Subj. Pres.—salga, salgas, salga, salgamos, salgais, salgan.
The other tenses are regular.

Venir, to come, *viniendo, venido.*
Ind. Pres.—vengo, vienes, viene, venimos, venis, vienen.
Fut.—vendré, vendrás, vendrá, vendrémos, vendreís, vendrán.
Past Def.—vine, viniste, vino, vinimos, vinisteis, vinieron.
Cond.—vendría, vendrías, vendria, vendríamos, vendríais, vendrían.
Imperat.—ven, venga, vengamos, venid, vengan.
Subj. Pres.—venga, vengas, venga, vengamos, vengais, vengan.
The other tenses of the Subjunctive have the regular endings applied to the stem *vin*. Example: *viniéra* or *viniese*, etc., *viniere*, etc.

Irregular Past Participles

The following verbs have irregular past participles:

	Past Participle.
Decir, to say, with all its derivatives (except *bendecir*—bendito, and *maldecir*—maldito), as *contradecir*, to contradict, etc.	*dicho, contradicho,* etc.
Hacer, to make, to do, and all its derivatives, *contrahacer* (to counterfeit), falsify, etc.	*hecho, contrahecho,* etc.
Morir, to die.	*muerto*
Poner, to put, to place, and all its derivatives, as *oponer*, to oppose, etc.	*puesto, opuesto,* etc.
Solver, to solve; this verb is obsolete, but its derivatives have the same form of past participle, as *absolver*, to absolve, etc.	*suelto, absuelto*
Ver, to see, and its derivatives, as *prever*, to foresee.	*visto, previsto*
Volver, to return, and all its derivatives, as *devolver*, to give back.	*vuelto, devuelto*

Double Past Participles

The few verbs which follow have a true double past participle. Other so-called double participles are simply adjectives, and can only be used with *ser* and *estar*. The true participle must admit of *haber*:

	Past Participle.
Freir, to fry; the second form is preferred with *estar*.	*freido, frito*
Injerir, to engraft; the first form is used with *estar* and *haber*, the second as "grafted" without auxiliary.	*injerido, injerto*
Oprimir, to oppress; the second form is not often used.	*oprimido, opreso*
Prender, to arrest; both forms may be used with *haber*, the second is most usual with *ser*.	*prendido, preso*
Proveer, to provide; the second form is most usual with *estar*.	*proveido, provisto*
Romper, to break, used both with *haber* and *estar*.	*roto*

Defective Verbs

Placer, to please, is used only in the third person, singular or plural, in the following moods and tenses; it is always accompanied by a personal pronoun in the objective case. Example: *me place*, it pleases me, etc.

Ind. Pres.—place	*Cond.—placería*
Imperf.—placia	*Subj. Pres.—plazca* or *plegue*
Past Def.—plugo or *plació*	*Subj. Imperf.—pluguiera, placiera, plugiese,* or *placiese*
Fut.—placerá	

Roer, to gnaw, is found in the following forms:
Ind. Pres.—roo, roigo, and *royo, roes, roe,* etc.
Subj. Pres.—roa, roiga, and *roya, roas, roigas,* and *royas,* etc.
NOTE. *Corroer*, to corrode, differs from *roer*, the *Ind. Pres.* being *corroe, corroen*, and the *Subj. Pres. corroa, corroan*.

Soler, to use, to be accustomed (past participle, *solido*), is only used in the following tenses:
Ind. Pres. Suelo, sueles, suele, solemos, soleis, suelen.
Imperf.—Solia, solias, solia, soliamos, soliais, solian.

Yacer, to lie, is chiefly used in the form of "*aqui yace*" in epitaphs. Other forms of the verb are rarely used. The following tenses are irregular:
Ind. Pres.—yazco or *yazgo, yaces, yace,* etc.
Imperf.—yace or *yaz, yaced.*
Subj. Pres.—yazca, yazcas, yazca, etc., or *yazga, yazgas, yazga,* etc.

Vocabulary—Vocabulario

A chest	Una arca	Gracefulness	Garbo (m.)
A bow, an arch	Un arco	The claw	La garra
The quiver	El carcaj	The gutter	La gotera
An arrow	Una flecha	Spinning	Hilar (m.)
The flannel	La franela	The spinning-wheel	La rueca
To charter a ship	Fletar un buque	Inaccurate	Incorrecto
The freight	El flete	Indigent	Indigente
Lazy	Perezoso	Infamy	Infamia (f.)
A florist	Un (una) florista	Unfortunately	Desgraciadamente

Vocabulary—Vocabulario

To inflame	Inflamar	A slate quarry	Un pizarral
A mountain	Un monte, una montaña	A pebble-stone	Un guijarro
Mountain-side	La falda de un monte	The clay	El barro
A vale	Un valle	The bar	La barra
A cave	Una cueva	To ripen	Madurar
The sand	La arena	Mature, ripe	Maduro
A whetstone	Una piedra de amolar	A sheep-fold	Un majadal
A brick	Un ladrillo	Foolish	Majadero
A roof-tile	Una teja	To commit suicide	Suicidarse
A slate	Una pizarra	Deformed	Deforme
		To be pleased	Quedar contento

Exercise XVIII. (1)

Translate the following into Spanish:

1. One cannot say, "I shall not drink of this water."

2. We are going to the theatre to-night. We shall go in a carriage.

3. Cursing his fate, he committed suicide.

4. Let us bless Providence for its benefits.

5. Let us hear the good advice that is given us, and, after hearing, follow it.

6. Come when duty calls you and rejoice at coming.

7. The world has absolved us of all guilt.

8. The son of Madam T. is deformed.

9. A despot oppresses those who surround him, but in oppressing makes himself hated.

10. They captured the assassin. He was taken after offering great resistance.

11. There is a shop which is called (calls itself) "general provider." It has provided for many from the cradle to the grave.

12. My watch is broken, and the servant broke the tumbler after breaking the dish.

Exercise XVIII. (2)

Translate the following into English:

1. En Holanda se encuentran arcas antiguas talladas con gran habilidad que son muy apreciadas.

2. El carcaj de Cupido está lleno de flechas traidoras.

3. Fuí al florista y compré flores escojidas y olorosas.

4. Con sus garras me arañó el gato.

5. El arte de hilar ha pasado de moda, antiguamente hasta las reinas hilaban, y con el hilo que producían con sus ruecas tejian lienzos muy finos.

6. Ese hombre se cree un escritor de primera, y es tan iliterato que todas sus citaciones son incorrectas.

7. El inflamar las malas pasiones de nuestro projimo es una infamia.

8. En las faldas de los montes se hallan musgo, heléchos, y césped silvestre.

9. A veces se encuentran en la arena á la orilla del mar guijarros de cierto valor.

10. Pusimos las manzanas y peras á madurar.

Key to Exercise XVII. (1)

1. Anduvimos de un pueblo á otro. Ando mucho sin cansarme, pero él no puede andar.

2. Le dí limosna á un pobre, me dá gusto dar al verdadero necesitado.

3. Yo quepo en ese sillón, y aquellos cupieron en el sofá, y el niño cabe en la cuna.

4. Podeis tomar ese manuscrito si es que pueden Vds leerlo. No puedo decifrarlo.

5. Ponga el pan sobre la mesa, y despues lo pondré en el aparador mientras ponen la mesa.

6. Quiero que me escuchen, y ellos no quieren oirme.

7. Mis amigos saben de memoria la historia de Inglaterra; yo sé muy bien la de España, y con el tiempo la sabrán ellos tambien.

8. Traigan á la vuelta la buena fortuna con Vds, y despues de traida, esperemos que se quedará.

9. Este cuadro no vale mucho, pero despues de limpiado valdrá mas, y no me extrañaria que entonces valiese mucho.

10. Veo que su amistad es dada á otro y viéndolo la mia disminúye.

11. Las fábulas de Lafontaine no son tan conocidas como las de Esopo.

12. La fachenda de ese hombre es ridicula.

Key to Exercise XVII. (2)

1. The tobacco factory of Seville is one of the curiosities of the town.

2. The people in Andalusia wear sashes of brilliant colours; the effect is very picturesque.

3. The word *fatiga*, besides being used with the meaning of fatigue, is used as an exclamation which means "how tiresome!" "what an affliction!"

4. In time of knight-errantry the knights received from the hands of their ladies a reward, which they kept and defended with their lives.

5. The National Gallery in London contains very good pictures.

6. The bulls which come to the towns for the bull-fights are always called the cattle.

7. There are beggars who, dressed in rags, still preserve some dignity.

8. The exploits of the Cid are known all over the civilised world.

9. Very pretty stuffs are made of cotton. Those of Manchester are the best.

10. At merrymakings the peasants dance round bonfires.

11. Humility is a virtue, but to humiliate the humble is the act of a despotic and proud person.

12. Ignorance is daring. No one gives a more decided and peremptory opinion than an ignorant person.

PROSE EXTRACT XV.

From "Notas sobre el Comercio Hispano-Británico en el año 1904."

One of the causes exercising the greatest influence on the reduction in the prices of some of the articles exported from Spain to the United Kingdom is the unmethodical manner in which the exportation is carried out.	Una de las causas que ejerce mayor influencia sobre el descenso en los precios de algunos de los productos de la exportación española al Reino Unido, está en la manera desordenada como dicha exportación se verifica.
The remarks which we are about to make may be applied to the export of articles of food, such as oranges, grapes, and raisins.	Las observaciones que vamos á hacer pueden aplicarse á la exportación de productos alimenticios tales como naranjas, uvas y pasas.
The losses sustained in the year 1904 in connection with the two last-mentioned fruits are attributable almost exclusively to the lack of some organisation in the Peninsula, which would regulate foreign exports, and avoid the agglomeration of a certain article in any one place at a given moment when the supply greatly exceeds the demand at a time when in another market the latter exceeds the former.	Las pérdidas experimentadas el año 1904, en los dos últimos productos antes mencionados, débense, casi exclusivamente, á la falta de un organismo ú organización en la Peninsula, que regule la exportación exterior, evitando la aglomeración de un producto en una plaza en un momento dado, cuando la oferta excede con mucho á la demanda, en tanto que en otro mercado la última es superior á la primera.

Thus, for example, (and) with respect to grapes, it happened that Almeria glutted the English markets with a very large number of barrels at a certain moment, the result being a very serious fall in prices. Fortunately, the demand was very active in America at that time, and the surplus barrels were immediately re-shipped to the United States, where a good price was paid for the fruit, and a catastrophe was thus averted.

The same happened with raisins. Our growers began by enormously exaggerating the value of the crop, which they estimated at an exceedingly short figure. Facts soon demonstrated the mistake which they made, and all at once the Eng-

Así, por ejemplo, y con respecto á la uva, resultó que Almería aglomeró en los mercados ingleses grandes cantidades de barriles en cierto momento, lo cual produjo una baja importantísima en los precios. Afortunadamente, la demanda era grande entonces en América, y los barriles que aquí sobraron fueron reembarcados inmediatamente para los Estados Unidos, donde se pagó bien el fruto, y así se evitó una catástrofe.

Lo mismo sucedió con la pasa. Empezaron nuestros cosecheros por exagerar enormemente la importancia de la cosecha, que calcularon en una cifra extremadamente pequeña. Los hechos vinieron á demostrar el error cometido, y

lish markets were flooded with a supply three or four times as great as the average consumption. And as every market has a limited power of absorption, the inevitable happened, and prices experienced a sharp decline. And, as if this by itself were not sufficient, Spanish exporters, observing that the Baltic markets were not buying such large quantities as in previous years, brought over to England the unsold parcels, thereby causing great congestion in these markets, the still greater depreciation of the raisin and the consequent ruin of many exporters, who lost enormous sums during that season.

de pronto inundaron los mercados ingleses con una cantidad triple ó cuádruple de la que ordinariamente consumen. Y como los mercados tienen un límite en su absorción, resultó lo que no podía menos de ocurrir, que los precios sufrieron un gran descenso. Y si esto por sí solo no era bastante, los exportadores españoles, viendo que los mercados del Báltico no compraban las grandes cantidades de años anteriores, trajeron á Inglaterra las sobrantes que por colocar allí tenían, causando con esto la congestión de estos mercados, la depreciación aun mayor de la pasa, y la consiguiente ruina de muchos exportadores, que perdieron fuertes sumas en la citada temporada.

Continued

ESPERANTO

Continued from page 4656

By Harald Clegg

ADJECTIVES—continued

The adjective may be placed either before or after the substantive which it qualifies or of which it predicates something. Example:

Li trovis tro forta la teon. He found the tea too strong.

Sometimes it happens that two nouns joined together by *and* are qualified by a single adjective, and in such cases the adjective must carry the plural sign *j*. Example:

Mi havas onklon kaj kuzon fortajn, I have a strong uncle and cousin.

This is an important point, because were the *j* omitted, it might appear that only the cousin was strong. When a plural noun is used and different adjectives are required to qualify singly each of the several objects signified by that noun, then the singular adjective must be used. Example:

Mi parolas la anglan kaj la francan lingvojn. I speak the English and French languages.

THE VERB (Future Tense)

The future tense of the verb is formed by adding *os* to the root. The conjugation is, as before, quite regular. Examples:

Morgaŭ mi vidos vin ĉe la koncerto, To-morrow I shall see you at the concert. *Ili estos feliĉaj paroli kun vi,* They will be happy to speak with you.

VOCABULARY

abon', subscribe
afabl', affable, kind
agrabl', agreeable
alt', high
amuz', amuse
ban', bath
bel', beautiful, fine
blank', white
brak', arm
cert', certain, sure
cigared', cigarette
ĉarm', charming
ĉiel', heaven, sky
danĝer', danger
dens', dense, close
detru', destroy
dik', thick, stout
eĥ', echo
ekstrem', extreme
facil', easy
gaj', gay, merry
gant', glove
glor', glory
hero', hero
honest', honest
ĵurnal', journal, newspaper
kaĝ', cage
kanari', canary
kapt', capture
kar', dear
lakt', milk (*subst.*)
lang', tongue
leter', letter (communication)
manĝ', eat
maten', morning
matur', ripe mature
mend', order (goods)
pag', pay
rezultat', result
riĉ', rich
rid', laugh
romp', break
rond', round, circle
saĝ', wise
san', health
sun', sun
ŝultr', shoulder
temp', time
trov', find
voĉ', voice

Exercise 4.

Yesterday I was ill. To-day I am well. The bird in the cage is a canary. He caught it yesterday. The cherries are ripe, and you can eat them. The box contains cigarettes and matches. He subscribes to the journal and the gazette. Dear sir. Time flies, and we must go out. Esperanto is easy. He has a letter in his (the) hand, and a newspaper under the arm. She has a white horse and a beautiful dog. To-morrow we shall go to the theatre. We shall laugh and be gay. He is rich and will pay you. The glorious hero will arrive to-morrow, and you will see him. The table is high and round. The lion is a dangerous animal. You will find the glove and the stick on the table in the garden. I wrote the letter, and he destroyed it. The general with the beard is stout and the poor soldiers are thin. They are wise and will amuse themselves. I can hear the echo. The cousin is disagreeable to-day. The sun is in the sky. To-morrow I shall buy the clock, and it will belong to me. The soldiers are honest and merry. The matter is difficult. To-morrow I will decide as to it, and you can be certain about the result.

ADVERBS

In Esperanto there are two kinds of adverbs, *i.e.*—

1. Those which are derived from substantival and adjectival root-words by the addition of a final *e*. Examples: *nokte*, in the night; *bele*, beautifully.

2. Those which are by nature adverbs, and have no distinctive final ending. These latter will be dealt with in a subsequent lesson.

The use of derived adverbs is very similar to that in English. They may be placed either before or after the verb, care being taken that their position gives the exact meaning desired. The necessity for this remark is shown in the following:

Li kantas laŭte kaj dancas.

Li laŭte kantas kaj dancas,

the correct translation of which is, "He sings loudly, and dances." In the second sentence the word *laute* might be considered to relate to *dancas*, which is hardly what is intended.

When these adverbs are used to qualify adjectives they are usually placed before them. Examples:

Ŝi estas vere bela, She is truly beautiful. *Li estis ekstreme malgentila,* He was extremely rude.

The prepositions may also at times be conveniently converted into adverbs by adding *e*, in which case the result is the same as prefixing them to verbs. Examples:

Li loĝas sube, He lives underneath. *Ni iris kune*, We went together.

Esperanto sometimes has a curious usage of the adverbial form where we use the adjectival. This is illustrated in the sentences:

Estas amuze legi, It is amusing to read. *Estas bele en la ĝardeno*, It is beautiful in the garden.

The reason for this is that the adjectival form would suppose a noun or pronoun to be present or understood, and, as in the above cases neither is to be found, the adverb is logically substituted.

The Negative. The negation is formed by the use of *ne*, no, not.

Contrary to English practice, it is placed *before* the verb. It is often convenient to prefix the negative directly to some of the parts of speech, as: *nebona*, bad (not good); *nelume*, dimly. When an adverb is used in proximity to the negative, the position of both must be carefully noted or the phrase may have a meaning contrary to that intended. Example:

Li tute ne komprenis.

Li ne tute komprenis.

The former sentence means that he understood nothing at all, while the latter implies that he only partially comprehended.

VOCABULARY

Akcent', accent
ali', other, another
apart', separate, apart
aprob', approve
bat', beat
blu', blue
boj', bark (of a dog)
brun', brown
ceter', rest, remainder
ĉef', chief, principal
dekstr', right-hand
detal', detail
divers', diverse, various
feliĉ', happy
franc', Frenchman
gratul', congratulate
hotel', hotel
kamp', field
kares', caress
kelk', some, several
knab', boy
koler', angry
korekt', correct
kovert', envelope
kred', believe
last', last, latest
laŭt', loud, noisy
lav', wash
leg', read, peruse
oft', often, frequent
okaz', happen, occur
ombr', shadow
ov', egg
poŝt', post (a letter)
prav', right, correct
reĝ', king
rigard', behold, look at, watch
silab', syllable
silent', silent
simpl', simple
soif', thirst
strang', strange
tre, very
urb', town, city
util', useful
uz', use
van', vain, needless
vang', cheek
vilaĝ', village
volont', willingly

EXERCISE 5.

You are right, and I am quite wrong. We must not stand in (on) the king's shadow. You will be happy, and I must heartily congratulate you. He was very angry, and wanted to beat me. The boys washed themselves in the river. You must go to the left-hand house. Some streets in the town are very ugly. He told me sundry strange details about the occurrence, and I willingly believed him. The eggs are bad, and you must not eat them. To live simply is to live happily. You may have the brown envelopes, the blue do not belong to me. In the silent fields he often sits and watches the birds upon the trees and the glorious sun in the heavens. Without a word he angrily went out. One often sees very strange houses in villages. They are extremely vain, and sit apart from us. The dog barks loudly. It is thirsty and wants water. Several boys wanted to open the window. The remainder did not approve the suggestion, and would not remain in the room. To-morrow morning we can be found at the hotel with the other gentlemen.

KEY TO EXERCISE 2.

La soldatoj iris tra la stratoj. Dimanĉo, lundo, mardo, merkredo, ĵaŭdo, vendredo kaj sabato estas tagoj de la semajno. En la nokto la filo aŭdis bruon. La akvo kaj la supo bolas. La patro parolis al la soldato pri la afero. La infanoj dancis en la ĉambro kaj la birdoj kantis sur la arbo. La generalo havis botelon da vino kaj petis glason da akvo. La ĉerizoj restis sur la arbo. Je vendredo kaj sabato la patro kaj la frato iris al la teatro por aŭdi la koncerton. Hieraŭ la pastro aĉetis funton da ĉerizoj, kaj hodiaŭ la filo de la generalo vendis botelon da vino al la kuzo. Jen estas pipo kaj la gazeto. Jen estas ĉerizoj kaj glaso de (or por) akvo. La leono havas dentojn. La akvo restis sur la tablo en la ĉambro. Jen estas amaso da viroj sur la strato. La sinjoro kaj la mastro aŭdis la bruon kaj parolis al la pastro pri la afero. La filo vidis la fraton ĉe la teatro. Ĉe la koncerto la sinjoroj kantis kaj la popolo ĝuis la muzikon. La birdo eliris tra la fenestro. En la mano la soldato havas bastonon.

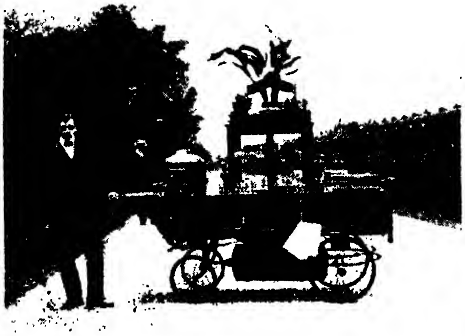
KEY TO EXERCISE 3.

Mi petas glason da biero kaj pipon. Vi devas estingi la fajron kaj la lampon. Mi aŭdis la blekojn de la ĉevalo kaj de la ŝafo. Li dubis pri la afero. Bopatro. Bofrato. La bovo apartenas al ŝi. Mi povas(a) kanti kaj danci. Jes, sinjoro, mi havas cigaron kaj alumetojn. Li mem estis en la ĝardeno. Ŝi helpis min kaj mi dankis ŝin por la propono. Ili donis al mi la libron kaj mi disŝiris ĝin. Li havas amikon kaj ŝi havas malamikon. Ili volas malhelpi vin. En la vintro mi loĝas en la domo kaj laboras. Ŝi decidis aĉeti la horloĝon. Vi citis la aferon al mi. Homo havas harojn, gorĝon, manojn kaj koron. La fajro brulas. Vi faris al mi proponon kaj mi akceptis ĝin. La alumetoj en la skatolo apartenas al ni. Mi konas vin kaj vi konas min. Hodiaŭ estas merkredo kaj hieraŭ estis mardo. La bofilo restas en la strato kun la kuzo. En la nokto la vento blovis. La leono vundis sin (mem). Ĝi blekis kaj faris bruon. Adiaŭ, amiko; mi volas danki vin por la helpo.

(*a*) NOTE. The verb following *voli*, *povi*, and *devi* is always infinitive: even when not actually used the infinitive is always implied. Example:

Vi povas skribi, kaj vi devas (skribi). You *can* write and you *must*.

Continued

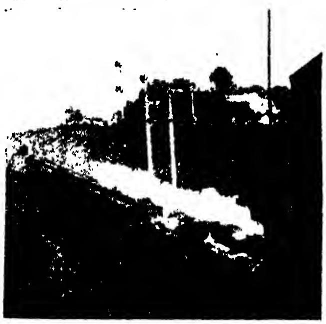


38. Platform Refreshment Stall, Midland Railway

39. L. & N.W. Rail Motor Coach

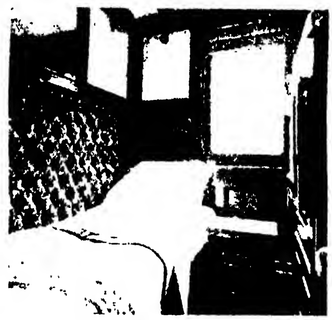
40. Steam Rail Car, with Cochran Boiler, on G.N. of S. Railway

41. N.E.R. Petrol Electric Autocar

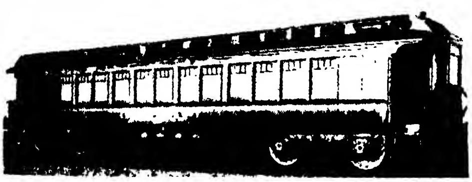


42. Express Train Slipping a Coach

43. Guard of L. & N.W. Main Line Express



44. Sleeping Saloon State Cabin on L. & N.W. Railway



45. Pullman Car

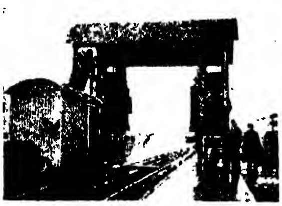
46. G.N.R. Petrol Rail Motor-car

47. G.W.R. Rail Motor-car with Trailer attached

MODERN RAILWAY PRACTICE

[SEE OVER]

48. Main Line Corridor Vestibuled Dining Car Express on L. & N.W. Railway

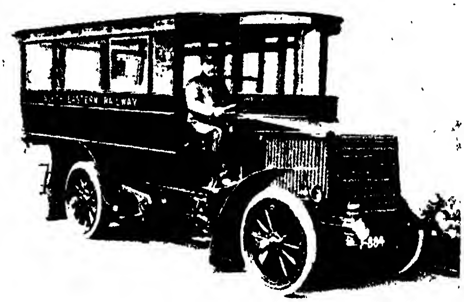


49. Mechanical Train Washer

50. Blanket, Pillow, and Rug Store, L. & N.W. Railway

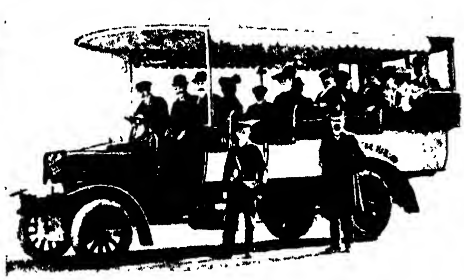
51. Rug and Pillow Barrow

52. Interior of G.W.R. Rail Motor-car



53. N.E.R. Chelmsford Passenger Motor 'Bus

54. Special Coupling Hook for Slip Coaches



55. Passenger Road Observation Motor 'Bus used by G.W. Railway Co.

56. Slip Coach, showing End Window

57. New Pattern Composite Dining Car. G.W. Railway Co.

MODERN RAILWAY PRACTICE

[SEE OVER]

RAILWAY MANAGEMENT
continued from
page 4697

THE PASSENGER TRAFFIC

The Passenger Train Staffs. The Modern Railway Passenger Train. Railway Comfort and Luxury. Railway Tickets and Railway Fares

By H. G. ARCHER

THE superintendent of the line, or general superintendent in the case of those companies which have divided the operating from the commercial side, is responsible for the preparation of the time-tables, both pubic and working. A public time-table, which refers only to the working of the passenger traffic, is issued twice or thrice a year—the summer train service, for the months of July, August, and September, and the winter train service, which remains in force from October 1st to June 30th following, though a few companies issue a third time-table for the months of May and June. It will be easily understood that there is a greater volume of passenger traffic in the summer, and a greater volume of goods and mineral traffic in the winter.

Time-table Work. A working time-table, which forms the real key to the working of the traffic, deals not only with the arrival and departure times of passenger trains at stations, but also fixes their passing times at junctions and stations where they do not stop, for the guidance of the staff. In addition, it gives the working of all goods, mineral, special, and empty trains and light engines; in short, every movement of traffic which takes place outside station limits. Can it, therefore, be wondered that a working time-table should be a ponderous volume which, as a rule, has to be issued in parts for the different sections of the system? The "heavy" lines publish a fresh working time-table each month, and every week, or sometimes every day, supplement it with addenda relating to the altered working necessitated by special trains, duplication of ordinary trains, and the exigencies of the engineering department. Some companies make use of diagrams, which are prepared for each section of the line, showing how the engine working is arranged, the time and speed of running, and the intersection of the trains where goods and slow passenger trains have to shunt for the express trains to pass them. The London and North-Western diagrams are drawn to scale, with perpendicular lines dividing the day of twenty-four hours into periods of hours, half hours, quarters of hours, and of five minutes; and with horizontal lines dividing the railway into sections of miles-chains; while slanting lines are inked in to represent the traffic timed to run over the line. Thus, the diagram offers a visible picture of the state of the line as to its being occupied or otherwise between any two points at any minute of the day, and with this type of diagram one can readily detect any abnormal speed of a train, wait at stations, length of day for the men, or idle time of engines.

Time-table Conferences. Before a time-table is materially revised, time-table conferences—usually summer and winter—are held, which meetings are attended by all the divisional superintendents, together with representatives of the locomotive department, and presided over by the superintendent of the line. Prior to the holding of a conference, suggestions for new trains or altered workings have reached the office from all parts of the system, and such suggestions which are invited must be accompanied by particulars, specifying reasons, likely advantages, and the total increase or decrease of engine and train mileage which each change would involve. The conference thoroughly threshes out these proposals, approving of some and rejecting others. Approved suggestions go to the general manager and traffic committee for ratification, after which the time-bill clerks attached to each divisional superintendent meet and work up the details, filling in the junction and passing times.

Rectifying Slack Train Working. It would be manifestly a herculean task to arrange the working of trains on a great railway from the very beginning without some previous knowledge of requirements and possibilities, but as traffic develops gradually the work is very much simplified. Of course, the superintendent of the line has to arrange his time-table in unison with that of a friendly foreign company, and at the same time to keep a watchful eye on the doings of competing lines, so as to be prepared to counter accelerations or new trains which might steal traffic from his own company. In arranging for a new train, the first difficulty is to get the others out of the way, and having put in the trunk, so to speak, the second difficulty is to feed and run off it by means of local trains, connections at junctions, and rail and road motor-cars, etc. "Train runners," or travelling inspectors, are attached to the office of the superintendent of the line. If from the reports that come into the office, either officially or privately, there be reason to suspect any slackness in the working of a train—if a train consistently lose time, or a locomotive be thought not to be doing proper work—a runner is despatched to travel by that train in order to locate and report upon the mischief. Similarly, goods train runners are sent out to various places to see how the working of the goods traffic can be improved.

Porters, Ticket-collectors and Conductors. The various grades of the staff associated with the working of the passenger traffic must now be explained.

Porters are divided into platform porters, earning 15s. to 19s. per week, luggage labelling porters, with 18s. to 23s. per week, luggage stowing porters, cloak-room porters and parcels-post porters earning 16s. to 18s. per week, the peculiar duties of each being explained by their designation, with the exception, perhaps, of the luggage stowing class. These latter, who are only found at the great terminal stations, are responsible for stowing passengers' luggage in the vans where it can be most easily handled during the journey. For example, the guard must not find his Exeter luggage buried beneath the Plymouth. Platform porters meeting trains are enjoined to attend to the compartments opposite to them, irrespective of class. The duties of ticket inspectors (35s. to 47s. per week) and ticket collectors (28s. to 35s. per week) are to examine and collect tickets, together with excess fares. The best men are selected to become travelling inspectors in corridor trains, where they are generally expected to act as conductors or attendants as well, while in some cases they fulfil the duties of junior guards, but without the pay of that rank.

The increase of corridor trains is, in fact, bringing into existence a distinct conductor class, which must not be confused with that of dining or sleeping-car attendants, and which is not necessarily recruited from the ticket collectors. Thus, the Great Northern Railway furnishes "lavatory attendants" on its "crack" trains, and the Great Western Railway recently inaugurated the practice of having male and female attendants to accompany its Cornish expresses. The Great Western male attendants do more than attend to the lavatories; their services are available for valeting a passenger, while the female attendants, who wear a kind of nurse's uniform, will chaperone ladies travelling unescorted, and look after children while their guardians are at meals in the restaurant-car.

Shunters. Very few shunters are employed in the passenger traffic department, as almost all shunting of passenger vehicles is performed by engines, while the movements demanded of this kind of rolling stock are comparatively few and far between. In the working of the goods traffic, however, a large army of shunters is required, and the duties of the men are far harder and call for greater intelligence than in the passenger service. Passenger shunters are practically confined to the sheds where the trains are marshalled. The grades of shunters are as follows: superior foreman shunter, foreman shunter (earning 25s. to 38s. per week), shunter, and assistant shunter (wages 18s. to 32s per week).

Guards. Just as the passenger train takes precedence of the goods, so the passenger guard, as a rule, takes precedence of the goods guard, although not a few among the latter are the better off in respect of pay. A guard [**43**] is responsible for the proper equipment of his train before starting, the safety and comfort of the passengers during the journey, and must, after the foregoing, give his next attention to the luggage, parcels, despatches, and other packets entrusted to him. Mail bags are usually accompanied by postal officials; when they are not, the guard is responsible for their safety. It is not generally known that railway companies send their own voluminous correspondence, as far as is practicable, by rail direct, instead of through the post, hence the guards of the night expresses are also called upon to act as sorters.

Duties of Guards. On joining his train, every passenger guard must have with him his watch, whistle, and carriage key, and take in his van a red and a green flag, not less than twelve detonators, and a hand signal lamp, which must be lighted when passing through long tunnels, and after sunset and in foggy weather. In the event of a breakdown the guard must protect the rear of the train by going back for a prescribed distance and placing detonators on the line. During the journey a guard has a good deal of clerical work to perform. Every parcel is accompanied by a way bill, which has to be checked, and any irregularity notified. Then, a guard has to keep a journal or "log" of his train, which furnishes a most important record as to proper time being kept, and illustrates a variety of other features concerned with the smooth and economical working of the traffic. In his journal he records the actual time of arrival at and departure from every stopping station; the number of minutes late away from a station; the time lost, and whether due to station, engine, or signals; if signals, whether they were ordinary or engineering signal checks; the number of carriages, carriage trucks, horse boxes, and vans taken on and put off; the number of wheels on leaving station where load is altered; remarks as to detentions at stations, and in running; general remarks, occurrences to trains, causes of delay, and suggestions for improvement of working; state of weather during journey, if wet, wind, frost, fog, or snow, between what points; particulars as to whether train was full or empty in each class of compartment; the numbers of the engines employed, and the names of the enginemen and the names of the junior guards. The journal of every through train is sent to the superintendent of the line or running superintendent, and that of every local train to the proper divisional superintendent. The journals of the previous day are carefully scrutinised every morning, and if the examiner find any delay or occurrence which is not, in his opinion, properly accounted for, he wires the divisional superintendent in whose division it happened for a full explanation. An improperly explained delay of as little as two minutes may involve an enormous departmental correspondence lasting for months, till the fault be ascertained. For instance, it may be discovered that the late arrival of a train at Yarmouth was due to a plethora of luggage put into a connecting train at Aberystwyth. A copy of every guard's journal is entered in ledgers at the office of the superintendent of the line, and so the minute history of all and sundry trains on each day of the year can be traced back for years.

Grades of Guards. The grades of passenger guards are according to the different ratings of trains, which classification usually comprises (1) through or express trains; (2) main-line stopping trains; (3) local trains. Some companies, or combination of companies, like those working a through Anglo-Scottish service, have a superior grade of guards, who accompany a train, say, from London to Aberdeen. These men wear a more elaborate uniform, and are dignified with the title of "conductor."

Wages and Promotion of Guards. The wages of passenger guards are from 23s. to 40s. per week; relief guards are paid 27s., pilot guards 25s. and porter guards 20s It may be noted that a guard of a long-distance through train is seldom as well off as his wages of 40s. per week would imply, inasmuch as some companies give these men no lodging allowance, and they have, therefore, to maintain what are practically two homes, one at each end of the line. Some companies, again, provide barracks for guards making long journeys. As a rule, a man is promoted straight to guard, and appointed to the charge of one of the least important local trains. But one or two companies have an intermediate grade in the shape of passenger brakesmen, who assist in local workings as required. During the holiday season, the services of goods guards, with whom it is the slack time of the year, are requisitioned to staff excursion trains. Two or more guards are carried only on trains which are heavily loaded with passengers, luggage, or parcels. The length or intrinsic importance of the train does not affect the question. The business man's city train invariably requires two guards, as one guard would not suffice to ensure smart working. Then, a train may start with only one guard, and pick up another further down the line. Where two guards are carried, with some companies it is a rule that the head guard occupies the rear van, and the junior guard the front, while with others it is just the opposite, as it is considered that the head guard should be in the van next to the engine. Some companies require all parcels to be placed in the front van, and luggage and mails in the rear; others, again, order it all to be equally divided, as far as possible, throughout the train.

Slip Coaches. "Slip" guards have to undergo special training, and their duties, which call for the exercise of considerable judgment and discretion, can be explained only by describing the practice of "slipping" itself—that is, attaching a carriage to an express train in such a manner that it can be detached at a station while the rest of the train, termed the "main train," passes on without stopping. The advantages of the system are obvious. It allows of "express" journeys to many places which are not of sufficient importance to warrant the stopping of an express train. "Slip" coaches are nearly as old as the railways themselves. One of the earliest lines—namely, the London and Greenwich—was worked in the "down" direction solely on the "slip" coach principle. The main train did not stop till it reached the terminus; meantime a carriage was "slipped" at every intermediate station. So long as trains were controlled by hand brakes in the guard's van, and on the engine, the slipping of coaches required no more complex apparatus than a special form of coupling. However, the adoption of automatic continuous brakes has compelled the use of additional apparatus, whereby the brake hose can be disconnected without impairing the efficiency of the brake power in either the main train or "slip" portion. There are two kinds of automatic continuous brake in use by British railways—the vacuum and the air—consequently the method of slipping with each differs somewhat. However, we will describe the process as carried out by a railway employing the vacuum brake. A "slip" coach is a tri-composite carriage, with a slip compartment at each end, equipped with a hand brake, a lever operating the slip coupling, a brake indicator, a brake setter valve, and vacuum guages. The main train is coupled to the "slip" coach by means of a special coupling hook [54], the jaws of which are released by pulling over the aforesaid lever. Underneath the latter is a diaphragm which, while a vacuum exists throughout the train, locks the lever. At the last stopping-place, a slip coupling cock is attached to the brake hose at the point of severance, and its handle is turned to the left, in which position the passage is open for the maintenance of a vacuum throughout the train. The switch of the vacuum brake indicator, contained in a little bracket table, is also turned to the left, so that the indicator displays a shutter inscribed in red letters, "Wrong to slip."

Slipping a Coach. From one to three miles away from the slipping point, the "slip" guard leans out of his end window [56] and pulls a cord which turns the handle of the "slip" coupling cock parallel with the hose. He next turns the switch of the vacuum indicator in the same direction. The result of these two operations is that the "slip" portion now forms a separate and self contained unit. The vacuum brake, as controlled from the engine, ends with the tail coach of the main train, while the slip portion has retained a residuum. Still, the slip coupling cannot be released, as there is a third vacuum holding down the diaphragm. Just before reaching the slipping point, which must be judged to a nicety, the guard lifts the handle of the brake setter valve a sharp hiss, and the vacuum locking the diaphragm is destroyed, while, at the same time, the indicator displays a fresh shutter, inscribed in white letters, "Right to slip." Then, at the right place, the slip guard pulls over the lever, whereupon the jaws of the coupling hook open, the brake hose parts at the joints, and the train is running in two portions [42]. With the London and North-Western Railway all the operations of "slipping" are accomplished more simply by means of a pneumatic apparatus. The rear guard of the

main train and the "slip" guard exchange signals, with green flags or lamps, to indicate that the "slip" has been satisfactorily effected. The momentum of the "slip" portion is checked with the hand brake, for the power stored in the power brake is reserved for use in case of emergency. The Board of Trade regulations prohibit "slipping" in a fog, and the companies' rules enjoin the "slip" guard to see that the "distant" signal is "off" before he slips. At night a slip portion carries a head light and also special tail lamps to distinguish it from those of the main train.

Responsibilities of the Stationmaster. Stationmasters are answerable for the security and protection of the office and buildings and of the company's property there. They are responsible for the general working of the station, the control of the staff, and the economical use of stores. They must take care that waiting-rooms, offices, platforms, and name-plates are kept neat and clean, and must also see that copies of the company's bylaws, Carriers' Act, list of fares, statutory and other notices are kept properly exhibited. At important stations the stationmaster attends only to the passenger work, and is accountable to the superintendent of the line, while his confrère, the goods agent, is responsible for the goods working, and comes under the control of the goods manager. There are stations of such little importance that the stationmaster is the only servant employed thereon, and acts as porter, parcel clerk, signalman, etc., as well; nevertheless, he ranks as a third-class stationmaster, and is uniformed accordingly. Second and third-class stationmasters are weekly-paid servants (wages 25s. to 47s.), who have risen from lad porters; while first-class stationmasters receive salaries, and, as a rule, are selected from the clerical staff. Lastly there is a specially high grade of stationmasters in command of the great terminal stations. Some companies make all their stationmasters except the last-named (who are expected to wear frock-coats and top hats) wear complete uniform. Others, however, confine the wearing of complete uniform to the second and third-class grades, first-class men being allowed to don mufti, though they must wear an official cap, while they garb their stationmasters-in-chief in an elaborate uniform.

The stationmaster of a London terminus is a very important official, and when a man has risen to this height the chances of his ultimately attaining one of the plums of the railway service are pretty well assured.

Traffic Inspectors. Broadly speaking, inspectors are divided into chief inspector, divisional inspector, inspector or sub-inspector, assistant or platform inspector.

The chief inspector is the divisional superintendent's right-hand man, for safe traffic working first, and for appointment and preferment of the staff secondly. With some companies he ranks as head of the weekly-paid staff; arranges all the duties of that staff, together with their annual leave, and when the engineering department requires occupation of the line, the arrangements are made through him. In any case, the chief inspector is constantly about the line, making suggestions and conveying instructions with the authority of the superintendent of the line or general superintendent behind him. He, too, is among the officials who accompany Royal trains. The next grade of inspector may be either divisional inspector, responsible to the divisional superintendent, or sub-inspector, in charge of a district, earning from 35s. to 47s. per week, and responsible for all detail work under the chief inspector. The assistant or platform inspector (wages 32s. to 50s. per week) is the stationmaster's deputy at every big station. Under the stationmaster he is responsible for the time-keeping, good order, and cleanliness of the station staff, for the prompt despatch of trains, and for the loading and unloading of luggage and parcels.

Train Formation. The stationmasters are responsible for the proper make-up of passenger trains, although they have to delegate their responsibility. Through passenger trains are marshalled in the carriage sidings or sheds attached to the starting place of such trains. A *programme* is prepared showing the fixed formation of every train—that is, the number of coaches, the class of coaches, the number of compartments, the lavatory accommodation, dining or sleeping cars, post office or parcels vans, milk trucks, horse-boxes, etc.; between what points each coach works, what vehicles are to be picked up or taken off on the journey, and what special vehicles are to be run on certain days of the week. But the *programme* does more than this. It shows how each of the coaches is balanced on the return journey. Only local trains run through intact to their destination and return in similar fashion; whereas through trains soon get split up. Therefore it is necessary to work out how each vehicle returns, and to state the hour when it is due back. Trains must always be formed in the order shown in the programme in order to determine the places on the platforms where the luggage and parcels are held in readiness.

Before a train leaves the carriage sheds the gas reservoirs and lavatory tanks must be filled, clean towels and fresh soap placed in the lavatories, tail and side lamps put on, screw couplings, steam heating pipe, brake hose, and communication cord properly fastened and arranged, and the gas lighted (except in the case of trains electrically lighted) on the by-pass if it is a night journey, and in the case of a day journey also if there are any tunnels.

Communication between Passenger and Guard. By the Board of Trade regulations every train that travels for a distance of 20 miles without stopping must be provided with a means of communication between the passengers and the guard. For many years this took the form of a cord running under the eaves of the carriage, which was wound up at the end of the train upon a drum in the guard's van, and at the other was attached to the handle of a special whistle on

the locomotive. The notice ran: "To call the attention of the guard or driver, passengers must pull down the cord. There are cords on both sides of the train, but that on the right-hand side in the direction in which the train is travelling is the one by which alone communication can be made." Imagine, as a writer pointed out, the nervous girl, or even the average, self-possessed male, in the moment of danger sufficiently collecting his or her thoughts to remember which was the right cord to pull, let alone the difficulty of reaching out to get at it. The southern lines were the first to improve upon the system. They adopted the principle of having two electric wires running through the train like two sides of a ladder, which are joined together in each compartment by a rung that is broken in the middle. Draw out the bell-pull in any compartment and the broken rung is instantly mended, the circuit closed, and a bell in the guard's van starts ringing. The awkward and inefficient cord communication is now a relic of the past. During the last two or three years the companies that formerly used it have adopted a standard train signal, which consists of a valve, with a small passage that forms a whistle, and a rod passing through the valve to each side of the vehicle, and having a red disc attached to both ends. Near each end of the rod is also attached a lever, to which is connected one or two chains, usually two, which pass along the inside of the carriage immediately over the windows and doors of the compartment. The pulling of either chain by a passenger will be followed by a gentle application of the brake and the whistle being sounded. At the same time the red discs change from a horizontal to a vertical position, and so indicate to the officials the carriage from which the communication has been made.

Train Working. The cleaning of carriages after a journey, and filling the axle-boxes with oil (for oil-boxes have almost everywhere superseded grease in the case of passenger rolling stock, and are now being fitted to the fast goods trains), devolves upon a cleaning staff, which, as a rule, comes under the locomotive and carriage department. Every passenger carriage at the end of a journey is as thoroughly cleaned both outside and in as time will permit—the floors washed, carpets shaken, cushions dusted, etc. At important centres the vacuum cleaning process is used. An ingenious apparatus for cleaning the exterior of carriages by machinery has been adopted by a few companies. This is a shed [49], inside and on each side of which are vertical roller brushes, together with pipes spraying water. The complete train, dirty and travel-stained, is drawn through the shed at a speed of 4 miles per hour. Directly the engine has passed through, the brushes, which are fixed to rocking arms, spring forward and lightly grip the carriages. A spray of water from a perforated pipe issues in front of and behind each brush. The brushes rotate at high speed, just like the machine brushes employed by hairdressers, being connected by shafting to the flywheel of a small gas engine, and geared like a bicycle with chains and sprocket wheels. A pair of small pilot brushes takes the window in hand, while the remainder scrub the entire woodwork, from the eaves of the roof to the footboard. The apparatus cannot be relied upon to remove grease, to get rid of which a carriage must be oil cleaned or washed with soft soap once a week, but it does everything that can be expected of cold water, and as a time and labour-saving arrangement gives satisfactory results. Before making a journey, all passenger rolling stock is inspected by train examiners, who, if they find any defect which does not affect the safe running of the vehicle, affix a green-coloured "For Repairs" label, while if the vehicle is found to be so badly injured that it cannot be used, a red "Not to go" label is attached. Another class of examiners are employed in tapping the wheels with long hammers for the purpose of discovering fractures. Train-examiners and wheel-tappers belong to the locomotive and carriage department.

Refinements of Station Working. In conclusion, a few lines must be devoted to several interesting refinements which have recently been adopted for smoothing the way for passengers. Information bureaus are being opened at the principal termini, where the prospective traveller may obtain gratis all the information he needs. The London and North-Western Railway has introduced a novelty at Euston Station in the provision of a writing-room for the convenience of passengers. There are facilities for correspondence, including a staff of typewriters, and for using the telephone. Passengers can have letters, telegrams, and messages addressed to them here; and a private room can be engaged for interviews. Train indicators have long been used to denote the respective platforms from which the different trains depart, and to enumerate the principal places served by the latter; but arrival indicators are a new feature. The latest kind of arrival indicator is electrically operated. It tells one the time each train is due, the number of minutes it is late, the names of the principal stations at which it has called, and the number of the platform where it will be berthed.

Train Lighting. Improvements of a revolutionary character in the lighting of trains have come to pass during the last decade or so. Most of us can remember the primitive vegetable-oil lamp, now happily a thing of the past. This was the earliest method of lighting railway carriages, and although it formed a byword of reproach on account of its feeble illuminating powers and general filthiness, while it entailed the employment of a special staff of lamp men, a very long period elapsed before anything better was devised. Compressed oil gas is now the standard illuminant for railway carriages.

Every railway company has its own oil gasworks, and the gas is conveyed from the works to the sidings, where the carriages are charged, in mains, to which valves and connecting hydrants are attached at suitable places. The storage cylinders, which hold about 100 ft. of gas and are

fixed to the under-framing of a carriage, are charged from the mains by means of flexible hose. However, gas cannot be consumed under the high pressure in which it is made, but has first to be passed through a regulator, which reduces the 150 lb. pressure to 1 in. of water, and admits gas at the same rate at which it is consumed in the single or duplex flat-flame burners. Each jet can be regulated, or all the jets in a carriage turned off or allowed to burn on the bypass by turning a key at the end of the carriage, while each carriage has a pressure gauge to indicate the pressure in the cylinders and the state of the supply. Non-"gassing" stations receive their supplies from travelling gas tanks. Experiments have been made with acetylene gas, but in this country they have not proved very successful. At the time of writing, trials are in progress with incandescent gas and small, inverted burners, and several companies already have carriages so fitted experimentally.

Electrical Train Lighting. Although oil gas is the standard method of lighting railway carriages, a large number of trains is lit electrically. There are at least three methods of electric train lighting—namely, (1) lighting entirely by accumulators; (2) lighting by one dynamo for an entire train; (3) lighting by one dynamo fitted to each carriage. The two latter methods entail the employment of accumulators.

The third—namely, that of a separate dynamo and accumulators for each carriage—is the one which has been practically accepted as the standard method. The dynamo for generating the current is suspended from the under-framing, and its pulley is driven direct by a belt from the pulley on one of the axles. As the lamps must be supplied at constant pressure, it is necessary to provide means to maintain the voltage of the dynamo constant over a wide range of train speed. This is usually accomplished as follows: After a certain limit has been reached, the dynamo always runs as at uniform speed and produces the same voltage, no matter how much the speed of the train may vary, which result is achieved by a compensating device attached to the dynamo. When the train is travelling very slowly, or is stationary, the lamps are fed from the accumulators alone, which are automatically connected to the dynamo by means of a mechanical governor. The accumulators are divided into two parts, each half acting as a regulator to the other, and, being always in connection with the lamps, the light remains perfectly steady. We are far from suggesting that the foregoing system represents finality in electric train lighting. Although this method of illuminating carriages by means of the energy of the moving train is in the abstract quite perfect, in practice the problems involved in its completely successful realisation are many and intricate, and are far from having been solved. Already rival systems are springing up, in which no attempt is made to control the speed of the dynamo, but the dynamo output itself is regulated to compensate for the changes in the speed of the train. Electric train lighting is, in fact, a very big subject, and is likely to occupy the attention of electrical engineers for many years to come. However, it cannot be denied that the system described has succeeded in producing an efficient and economical light, while it also provides a ready source of power on a small scale for actuating bells and cooling or ventilating machinery in the carriages and restaurant cars. When trains are electrically lighted the guard is responsible for switching the current on and off.

Heating of Carriages The heating of carriages forms another phase of work associated with the comfort of the travelling public upon which much skill and ingenuity has recently been brought to bear. The rudimentary apparatus that long held the field was the foot-warmer—an oblong tin filled with water through an orifice, which was then hermetically sealed, and the warmer placed in a boiler until the water was heated. Like the vegetable oil lamp, this cumbersome apparatus necessitated setting aside a special staff of men to fill, heat, and distribute. Eventually it was realised that an efficient, simple, and economical method of heating could only be achieved by mechanical means.

Mechanical heating was first introduced into this country from America about the same time as Pullman cars [45] by the Midland and Brighton companies, the system being that of high-pressure hot-water pipes, fed from a boiler heated by a coke stove. This method is still employed in not a few sleeping cars, but, as it requires the constant attention of an attendant it is unsuitable to an ordinary train.

Rival Methods of Steam Heating. The two different methods of train heating which are standard at the present day are direct steam heating and dry steam storage heating. The former requires but a brief description. A pipe runs throughout the train containing exhaust steam from the locomotive. Dry steam storage heating, which is more elaborate, is managed as follows. The steam is taken direct from the boiler of the locomotive and passed to each carriage of the train by means of a main steam pipe. From the latter it passes through a branch pipe to a series of storage heaters, one of which is found beneath each seat. A storage heater comprises a wrought-iron boiler tube, closed at both ends, and filled to seven-eighths of its capacity with a strong solution of brine. The steam is thus brought into contact with the interior tubes, whereupon the brine contained in the latter absorbs a part of the heat, which is then gradually given off at a lower temperature than would be the case with any method of direct steam heating at similar pressure.

A regulator affixed to the back or side of the compartment permits of a passenger shutting off the heat or re-admitting it as desired. These heaters require no repairs; the strong solution of brine, of course, is proof against freezing, while the special form of steam pipe coupling between coaches is unfreezable, absolutely steam-tight, and uncouples automatically when

any two carriages are drawn apart. In order to obviate the discomfort of entering cold carriages, arrangements are made for heating trains at terminal stations before the engine couples on. A stationary boiler supplies steam to a main running alongside the platform, and this main is temporarily connected to the carriages at one or more points by means of flexible hose.

One company—the North British—have adopted a combination of the old foot warmer and steam heating systems. Fixed foot warmers, charged with acetate of soda, have high-pressure steam turned into them from the locomotive while the train is stopping at a station.

Electrical Heaters. Lastly, electrical heaters are occasionally met with in dining saloons. The heaters are compact in form; there is nothing of a combustible nature used in their construction, and a free circulation of air against the heated wires is provided for. The heaters are fed from accumulators, which in turn derive their current from the dynamos, driven by belts attached to the axles.

Sleeping Cars. Although there is in this country of short-distance journeys nothing approaching the same extensive field for its employment as exists in America and on the Continent of Europe, the British sleeping car is the most comfortable, the best equipped, and also the cheapest in point of the additional fee demanded for its use in the world. At present, sleeping accommodation is limited to first-class passengers, which is the rule almost everywhere, but it would not be surprising if we were soon to find an extension of such facilities to second and third-class travel. An improved pattern of corridor sleeping car has long been the standard on British railways. The car is divided into a number of state-rooms [**44**], entered from the corridor. These rooms, as a rule, hold one berth—never more than two—some being convertible into one or two bedded compartments. The berths are arranged transversely, which position has been found to yield greater comfort than the longitudinal. Upper berths, unpopular and rarely occupied, have quite disappeared. The bed is no shake-down affair, for its furniture comprises mattress, blankets, linen sheets, rugs, pillow, and bolster.

58. WEST COAST STANDARD SLEEPING CAR

Each berth compartment has its own washing-stand and other toilet fittings. The London and North-Western Company's latest sleeping cars [**58**] are 65 ft. 6 in. in length, and carried on two six-wheeled bogies. They are electrically lighted, steam heated, provided with electric bells, a lavatory at each end, a buffet, from which tea, coffee, and mineral waters are served, and a smoking compartment, while a supply of hot water is among the toilet refinements. Notwithstanding their great weight—namely, 41 tons—they can accommodate only eleven occupants, each of whom, therefore, accounts for some 3½ tons of dead weight. Prior to 1903 the supplementary fee for all this luxury was but 5s. over and above the ordinary first-class fare. In that year, however, the Northern companies raised the fee on the longer journeys to 7s. 6d. When a car arrives at a terminus earlier than 8 a.m., the occupants may remain in it until that hour.

Staffing and Stocking. A service of sleeping cars is managed by the superintendent of the line, while the carriage department is responsible for preparing the cars for the road, washing and mending the bed furniture, etc. The stock of bedding kept by the North-Western Company comprises: 1,998 mattresses, 4,868 mattress covers, 4,617 sheets, 2,267 rugs, 2,841 pillows, 8,081 pillow-cases. There are special halls at Willesden [**50**], where the bedding is kept aired and sorted ready for use. Every car is in charge of an attendant or conductor (wages 25s. per week), who attends to the comfort of passengers. He cleans their boots; brushes their clothes; takes charge of their tickets and collects excess fares, so that their rest may not be disturbed; serves them with tea or coffee, which he prepares in his pantry; and regulates the heating and ventilation of the car. The position of sleeping car attendant is a coveted post, for naturally it carries with it perquisites in the way of tips. Only thoroughly intelligent and cleanly men of unimpeachable character are selected for the work, and, broadly speaking, they are promoted from among the ticket collectors and head porters. The inmates of a car generally look to the attendant for help and advice concerning their journeys, hence, the latter must be well acquainted with the time-table, and able to display an intelligent interest in the travelling affairs of those under his charge. For the benefit of those who are unable to afford the luxury of a "sleeper," pillows and rugs may be hired from the company, as shown in **51**. These articles are trundled about the platform in glass-covered barrows, so as to ensure perfect cleanliness before issue.

The Travelling Restaurant. Dining-cars were given to the world by America. As might be expected, their introduction has been largely responsible for the increased weight of trains. Cars range from 60 ft. to 70 ft. in length, and weigh from 35 tons to 40 tons. The small compass within which a host of articles in everyday use is carried on board ship is constantly quoted, but a far more remarkable system of stowage is observed on board a dining-car, where also the risk of breakage is greater. The kitchen and pantry take up about a quarter of the length of the car, and from these confined premises a train like the Scotch express is sometimes called upon to serve 200 luncheons, 150 teas, and 200 dinners, all within the space of time of 8½ hours. The early kitchen-cars were equipped with coal-stoves. These were subsequently superseded by gas-stoves, while the *batterie de cuisine* comprises a gas-grill, ovens, refrigerator,

plate-heater, carving-table, cupboards, sinks, and separate boilers for washing-up and for making tea.

Organisation and Staffing. The dining-car business has now attained such vast proportions that it necessitates the employment of a special organisation and staff. Most companies place the management and catering of the cars under the chief of the hotels and refreshment department, while one at least has a special officer who, although he draws many of his stores from the hotel department, otherwise works independently of the latter. Under the hotel chief is a salaried officer who acts as maître d'hotel to the dining-cars. He may be seen inspecting the cars before a train starts, to satisfy himself that all is in order. The staff of a car consists of page attendants, second attendants, a head attendant or conductor, a kitchen porter, a carver, and one or two cooks. The staffing of the cars may be described as an Englishman's job. Without exception, the companies refuse to engage foreigners to wait upon passengers, while some give preference to English cooks. Lads are taken as page attendants between the ages of 14 and 15, and if they give satisfaction they are certain to become head attendants in time. Adults are also engaged as attendants, but the choice of such is practically limited to men who have been waiters in the company's refreshment rooms or footmen or butlers in private families. Railway directors are deluged with applications from private servants, especially those who have married or who are contemplating matrimony, as this coveted post enables them to settle down.

The head attendant or conductor is responsible for the provisions, which are invoiced to him, also for all stores, wines, etc., while the service staff generally is charged with the cleanliness of the cutlery, linen, and plate.

Provisioning. The provisioning of cars is arranged for at terminal and important intermediate stations. Broadly speaking, the food is cooked on the train, but prepared beforehand. Thus, soups and sweets have only to be heated up, whereas fish and joints have to be cooked while the train is travelling at full speed. The Great Central procedure is to have all the food brought aboard direct from the vendors—the fish from the fishmonger, the game from the poulterer, and so forth—and handed over to the dining-car *chef* direct. At Euston you may see an array of culinary offices, under the supervision of a chief *chef*, who draws up all the menus for the day. In one kitchen sweets and soups are being prepared; in a scullery vegetables are being washed; in a larder joints are being cut up and fish prepared; in a still-room groceries, pickles, cheese, and fruit are being made up into parcels; and in a linen-room maids are checking linen home from the wash, and mending it. All the comestibles for each car, together with a separate package containing tablecloths and napkins, are packed in a large hamper, which has just been steam scoured, and despatched to the proper train. Dining-car cooks form a distinct class, which has come into existence during the last fifteen years. A cook who joins without experience is sent for a week or so up and down the line in company with an old hand to learn his business.

At the end of a journey a car is gassed and watered by the carriage department, which is also responsible for cleaning all parts of it except the kitchen and pantry, this latter task being the duty of the car staff. Some companies have very stringent rules relating to the removal of any food over, the penalty being instant dismissal if so little as the tail of yesterday's sardine be found in a car on the following morning. The washing of the soiled table-linen sometimes falls to the carriage department, and sometimes to the hotel department. By aid of the invoice system it is possible to ascertain exactly how each car is paying. Dining-cars are now a profitable enterprise, but they are not run with the idea of making big profits, the management being quite satisfied if they just pay their way. Most companies now serve *à la carte* refreshments, except during the service of meals.

Refreshment-room Catering. The majority of railway companies have taken over the ownership, management, and catering of all station refreshment rooms. In doing so they have been actuated not so much by the desire to establish a fresh source of revenue as to study the comfort and convenience of passengers. It was found that private ownership sometimes led to abuses. It goes without saying that the management and staffing of the refreshment-rooms is a large business of itself, but as it cannot be said to form a part of the railway industry proper, it need not be described. One new and welcome feature may, however, be noted. The spread of restaurant-car facilities, perhaps, has pampered the travelling public; at any rate, the more enterprising companies have come to the conclusion that, in the case of non-restaurant-car trains, it is good business to bring the refreshment counter to the doors of the carriages, and so obviate the necessity of asking persons to leave the train and walk a few yards. The travelling refreshment stalls [38] inaugurated by the Midland do this. Equipped with boiler, urns, and ice-safe, they perambulate the platform, and serve out tea, coffee, soup, etc., freshly made.

The Advantages of Rail Motor-cars. The employment of what are called *rail motor-cars* is a very remarkable development that has taken place on British railways during the last few years. From the outset the enterprise was attended by such marked success, inasmuch as it at once proved its ability to solve so easily some of the problems of the traffic manager, that at the present time there is scarcely a railway of importance which has not adopted this new type of vehicle containing its own motive power.

The idea of rail motor-cars is that they furnish better accommodation, and secure more economical results in working the passenger traffic under certain conditions, which may be enumerated as follows. First, in the case of suburban traffic which encounters competition on the part of electric tramways, the rail motor-car enables

a railway company to afford facilities for cheap and rapid transit during those periods of the day when the number of passengers to be carried does not warrant the running of heavy engines and long trains, these latter being reserved to meet the stress of the morning and evening traffic. Secondly, where rural branch lines are concerned, the rail motor-car can be used to fill a void by giving a far more frequent service than it would pay to do by means of ordinary trains. The general manager of a rail-

59. STEAM RAIL MOTOR-CAR ON G.W. RAILWAY, WITH DETACHABLE ENGINE

way company largely employing such cars for this particular purpose states that the cost of running a rail motor-car as compared with a train is as 5½d. for the former per train mile, as against 1s. 3d. for an engine, with four coaches, per train mile. By means of rail motor-cars, therefore, both the railway company and those residing on branch lines benefit, while as the cars can also be used to stop between stations, at level crossings, and at other places where roads are close to the railways, they give access to districts which formerly laboured under the disadvantage of being situated some distance away from a station. These intermediate stopping-places are called "halts," and it is necessary only to furnish them with a low platform and a small waiting room.

Different Patterns of Cars. It is not possible to describe all the different patterns of cars now in use on the different railways, but the principal points of distinction between various types may be touched upon. From the road automobilist's standpoint, the term "rail motor-car" is, however, somewhat of a misnomer, as it gives him the impression that these cars are operated with an internal combustion engine, consuming petrol, whereas there are only two or three instances of this latter kind of engine being adapted to rail motor-car work. At present the vehicles are divided into three classes, *viz.*, (1) steam-operated; (2) petrol-electric operated; (3) petrol-operated, by means of an internal combustion engine. The sum total of the two last types numbers about half a dozen, while there are several hundreds of steam-propelled cars in service.

Common Characteristics. A steam-driven rail motor-car combines on one frame an engine and a passenger car of moderate seating capacity, the total length of the vehicle varying between about 55 ft. and 70 ft. The car is carried on two four-wheeled bogies, that at the trailing end being usually a standard passenger coach bogie, and the other forming a four-wheeled outside-cylindered locomotive of small dimensions. Sometimes the locomotive is complete in itself [59] when detached from the car frames, and may, if required, be run separately for shunting purposes, which are almost indispensable in railway working, while in most other cases the engine bogie is detachable [39], and the boiler and chimney can pass through an end door, in order that a defective engine can be replaced. The engine can always be operated from either end of the car, by means of a duplication of the stopping and starting apparatus, whistles, vacuum, steam, and hand brakes; for the essence of a rail motor-car is that it can be worked as a shuttle — that is, without having to be turned round in order to keep the engine foremost. A special arrangement provides that the vibration from the engine body is not transmitted to the body of the car.

Types of Boilers and Valve Gearing. There are several different types of boilers —namely, a smaller pattern of the ordinary locomotive type of boiler, with or without a Belpaire firebox, and carried horizontally; a vertical multitubular boiler, which kind is the most popular; and a novel generator of the vertical type [40]—namely, Cochran's patent boiler. This last possesses a minimum of joints and welds, and has no rivets or welded joints in actual contact with the fire. The feature, however, which takes pre-eminence is the facility that is afforded by the boiler design for obviating internal scaling. Scale formation is an important factor in the life of any boiler under all and sundry conditions. Failure by burnt plates or tubes, and consequent early scraping of boilers, generally arises from inability to get at the interior so as to clean effectively. The accessibility of all parts of the Cochran boiler for the latter purpose forms its chief claim to consideration. Sometimes the valve gear is worked by ordinary eccentrics, which are fitted on the driving axle instead of on the frame, and which actuate the valves on the top of the cylinders by means of a rocking shaft from ordinary link motion. More often, however, the cylinders are actuated by the Walschaert valve gear. Sufficient water is carried for the service in a tank or tanks placed below the carriage body, and there is also room for a supply of fuel in the motor compartment or elsewhere.

Arrangement of the Carriage. The carriage itself is divided into two or three saloon-like passenger compartments [52], a guard's and luggage compartment, and a driver's compartment at the opposite end to the engine-room, all having corridor communication; while the entrance to the car is generally effected by gangways fitted with collapsible gates. Electrical communication or speaking-tubes are furnished between the driver's and guard's compartments. For convenience in stopping at "halts" at which no platform is provided, there

are steps on each side of the car, which can be either covered by hinged flaps when the car draws up at an ordinary platform, or swung back to the width of the ordinary footboard by a lever. With some cars the outward movement of the steps opens a valve in the main vacuum pipe, and so prevents the car from starting till the steps are locked in running position.

The North Eastern Railway employs a few petrol-electric autocars [41], with which the generating power is a four-cylinder petrol engine, 80 B.H.P., that drives a dynamo direct, which, in turn generates current for four motors, one on each axle of the vehicle.

Petrol Cars. The only purely petrol-propelled, internal-combustion engined cars are found on the Great Northern and London and Brighton and South Coast Railways [46]. These vehicles are much smaller than any of the steam and petrol-electric cars, being only 34 ft. 6 in. in length, weighing 11 tons, and being carried on four wheels. The motive-power consists of two four-cylinder petrol engines, which drive both axles, while provision is made for two speeds in either direction. There is a driver's compartment at each end.

"Trailers." The seating capacity of a steam rail motor coach varies according to its size from 50 to 64 passengers. The more powerful cars [47] are capable of hauling a "trailer" coach, and they are also calculated to attain a speed of 30 miles per hour within 30 seconds of starting; while but few cars are designed to run at a higher rate of speed than 45 miles per hour.

Before ending the description of rail motor coaches, mention must be made of a later development upon the same lines. Several companies have fitted small side-tank engines to work with "trailer" cars as complete units. Engine and coach are never uncoupled while in service, and duplicate gear in the driver's compartment of the coach, at the end farthest from the locomotive, enables the unit to be worked either end foremost.

Management and Staffing. Rail motor-cars are under the control of the chief mechanical engineer, which he exercises through the district locomotive superintendent in precisely the same way as he looks after engines. It is not improbable, however, that as the employment of the cars becomes more extensive, a special department will be called into existence for the purpose of supervising them. A feeling is growing that since rail motor-cars constitute what is an essentially light, rapid, and mobile form of traffic, they require something less ponderously inclined than the brains of the locomotive department to study their needs and devise technical details.

The staffing of the cars is as follows. The steam-propelled vehicles require the services of both a driver and a fireman, as there must be a man in charge of the boiler. Therefore, when a car is running engine-room hindmost, the men part company, the driver being in the motor compartment in front (which, it will be remembered, is equipped with duplicate controlling gear), while the fireman remains behind. Some companies make the fireman act as guard or conductor as well, but the general practice is to employ a third man. The duties of the conductor of a rail motor-car are the same as those of a passenger guard in seeing to the needs of passengers, looking after luggage, and attending to the safety of the "train." In addition, he often issues and collects all tickets, and when the car stops at a "halt," acts as the station-master, porter, etc., of that "halt." The operation of a car fitted with an internal combustion engine can be entrusted to one man, the driver or motorman, a fireman being unnecessary. Drivers or motormen, together with the firemen of rail motor-cars, are drawn from the staff of enginemen. Conductors are selected from men who aspire to become full-fledged passenger guards; in fact, this service is now regarded as a training field for the latter.

Passenger Road Motor Traction. The functions of passenger road motor-cars are, broadly, to act as feeders to the railways, and so to promote travel in every capacity; while, incidentally, they also serve to exploit tourist districts, to form an efficient substitute for light railways, and to render possible a complete service over a new railway route, starting from rail head, pending the completion of the construction of the line.

Practically every railway-owned passenger road motor vehicle is petrol-driven, and among the different types of bodies used are: (1) double deck omnibus; (2) single-deck omnibus [53]; (3) observation or char-à-banc [55]; (4) open waggonette; (5) composite goods, mail, and omnibus. Each type of vehicle has accommodation for a certain amount of passengers' luggage, together with parcels, and many of them also make a speciality of the conveyance of packages containing agricultural produce, so that a service may fulfil an additional purpose in the way of bringing markets nearer to producers or of opening up to the latter new areas of supply.

Passenger Tickets. Passenger tickets comprise: (1) ordinary tickets, issued for ordinary trains at ordinary fares; (2) blank card tickets, used for light traffic only—that is, where there are few passengers between a pair of stations in a month, and on which the name of the destination station is omitted; (3) tourist and week-end tickets at reduced fares; (4) excursion tickets, printed specially for each excursion; (5) circular tour tickets, which take the form of booklets of coupons; (6) market, fishing, golfing, hunting, etc., tickets at reduced fares; (7) periodical, season, or contract tickets, which are specially printed, and require, as a rule, the holder's signature; (8) officers', soldiers', seamen and police tickets, at reduced fares, which are kept in books with counterfoils, and which are issued on the production of orders signed by the proper authorities; (9) workmen's tickets at reduced fares, which are available only by trains running at specified hours; (10) pleasure party tickets, which save stamping, say, 150 separate tickets to the members of a school treat; and (11)

privilege tickets, issued to the company's servants. Further, tickets for the conveyance of dogs, bicycles, perambulators, etc., or any other articles carried at owner's risk, are issued at the passenger booking-office.

Manufacture of Railway Tickets. Some companies print their own tickets, and others contract for them, while some do both; but in all cases the ticket printing establishment is under the close supervision of the company's accountant, who exercises a constant check on the supplies.

The manufacture of railway tickets, as carried out by the London and North-Western Railway at Euston Station, may be described as a representative process. The first room entered is where the multi-coloured sheets of pasteboard are received from the paper makers, and where the sheets are stored, and passed through machines which cut them up into the little cards with which we are so familiar. The first machine snips off the rough edges and divides each sheet into a number of longitudinal strips of the required breadth, while the second machine is fed with the strips, and cuts each into so many cards of the correct length. The cards issuing from the latter machine are ready for printing, and are carried by tray loads into an adjoining—the composing, printing, and counting—room.

Ingenious Automatic Machine. Great ingenuity has been brought to bear in the perfection of ticket-printing machines. The latest patterns may be described as being self-acting in every respect. The blank cards are fed into a hopper on one side, whence they descend and pass through the machine in an endless stream so long as the supply lasts, one card pushing the other forward. In the body of the machine each card is impressed with its proper consecutive number, has its face printed with the names of the issuing and destination stations, class, fare, etc.; is then turned over so that its reverse side may have imprinted on it a short notice beginning "Issued subject to the company's regulations," etc.; after which it is turned face uppermost preparatory to leaving the machine by another and similar hopper, in which the column of finished cards is pushed upwards. These machines can print from 10,000 to 14,000 tickets per hour. The supply of ink is automatically fed to the rollers, and in the event of a slightly torn or crumpled card being encountered, the machine stops of itself, and declines to continue printing till the offending specimen has been removed. Lastly, the printed tickets are passed through a machine which automatically counts them in batches of 250 at a time, and records the total number which has passed through it. Here, again, the cards are placed in a hopper, and the attendant turns the handle of a dial to the number borne by the first ticket to enter the machine. The machine is then set going, and automatically stops when it has counted out 250 cards into a hopper below. The attendant must see that the dial records exactly that number, and that it tallies with the number of the last ticket, otherwise one or more tickets must have got lost, or duplicates as regards the successive numbering been printed, in which case very careful search has to be made to rectify the error, for a printed ticket is treated as representing its face value in cash. The latest type of ticket-counting machine can deal with 20,000 cards per hour.

Number Check on Tickets. The company's audit accountant is the only officer through whom passenger tickets (save, in some cases, season tickets, which are supplied by the General Manager) may be obtained by the clerks in charge of the booking offices.

All tickets are type-numbered consecutively at both ends from 000 to 9999 inclusive (to avoid printing five figures when the limit of 10,000 is reached), and are marked to indicate the "series" to which they belong, ten thousand of each kind, class, and station making a "series." By the Regulation of Railways Act, 1889, Sec. 6, the fare must be written or printed on every *ordinary* ticket. The different colours and distinctive markings assigned to the tickets for various classes and specific purposes are legion, while there is a curious want of uniformity among companies in the colours that distinguish the classes.

Booking Offices. Inside the booking office, the tickets are kept in rows of "tubes" so-called—really two pieces of wood joined by a spring—which tubes are contained in lock-up cases of various sizes. The name of the destination station and fare is written above each tube, and the number of the next to issue is written on a strip of slate below the tube. The system is to place tickets in the tubes with highest numbers at the top, and, when booking passengers, to draw from the bottom, so that, after the departure of a train, by deducting the number written upon the slate from the number on the next to issue it is readily ascertained how many have been issued by that train. Below the lock-up cases are chests of drawers containing bundles of tickets to replenish the tubes. At large stations the arrangement of the booking hall is very methodical, the apartment being divided into classes and districts, with a separate window for each, while the case containing tickets most frequently used is placed nearest the window, and the remainder branch out in geographical order.

Renewing Stock of Tickets. Here, too, the staff comprises not only clerks to issue tickets, but a ticket stock-keeper, a cashier, and a chief booking clerk, each of whom has his own office within an office. The stock-keeper periodically replenishes from his own stores the drawers below the lock-up cases, and when he finds that a series of one class between a pair of stations is nearing exhaustion he fills in a "Ticket Demand Note," specifying the name of destination station, route, colour, class, description, fare, number of ticket which will be issued last, and the last progressive number of tickets in stock.

This demand note is signed by the chief booking clerk and sent up to the accountant's office, where it is checked and compared with the Ticket Stock Registers. Each issuing station has an account in the stock registers,

and the following particulars are inserted in their proper columns: name of each destination station, route, class, description, date of demand, last progressive number of tickets supplied, and quantity supplied in bundles of 250, and date of last supply.

Booking Clerks. Immediately after the departure of each train, the "train book" is made up, showing an account of tickets issued, a separate entry being made for each station and class. The "commencing number" is copied from the slate, and the "closing number" from the ticket next to issue, while the number of each blank card ticket issued has to be entered separately. After the train book has been made up, the old "commencing number" is wiped off the slate, and the old "closing number," now the "commencing number," written up in its place, when the clerk begins booking for those stations again.

At the close of the day a "Proof Sheet," or Daily Classification Book is made up, giving an account of every ticket issued, but before attempting to balance the day's takings the number of tickets that has been issued is balanced in a "Taking Out Sheet." At intervals during the day the clerks have been paying in "on account" to the cashier of the booking office, and on the following morning between 9 a.m. and 10.30 a.m., the whole of the takings of the day before are paid to the chief cashier in the accountant's office, and there balanced with the daily classification book.

Checking the Receipts. The takings and tickets issued by each individual clerk are made up separately, so that any individual loss or surplus may be located. The foregoing is the procedure followed at the great terminal stations, where on certain days of the year, the eve of a Bank Holiday, for instance, the number of tickets issued runs into tens ot thousands, while the cash receipts total thousands of pounds. And the same system applies on a more or less modified scale, according to its importance, at every issuing station on the railway. At ordinary stations, the stationmaster is responsible for the work of the clerks, and at small stations he issues the tickets and makes up the books himself. For the collection of cash receipts and used tickets, the line is divided into districts. Specially constructed safes travel up and down the line between district headquarters by passenger train, and into these receptacles the stationmasters of intermediate stations place their takings in bags, for which the guard of the train signs, while leather cases containing the collected tickets are also delivered into his charge.

At the district headquarters the cash is banked as soon as it is received, while the account sheets and collected tickets are forwarded every month to the chief audit office. The daily classification books are not sent up to the audit department, but at the end of each month the whole of the commencing numbers are taken off from the tickets themselves, and worked out on the month's issue. This monthly total must balance with the totals of the daily classification books.

The Monthly Audit System. The task of getting out the monthly audit of the receipts from all coaching traffic is very laborious, and necessitates the employment of a special staff of clerks and ticket sorters, the latter consisting of boys, or sometimes women. Each collected ticket has to be sorted back into its proper series of kind, class, and station, and a note taken of missing numbers and tickets irregularly issued. Directly the monthly audit is completed, the sorted tickets (save those of the blank card type) are defaced and destroyed, but blank card tickets are kept back for another month before being consigned to oblivion.

Schedules of missing tickets are sent every month to the station responsible for an explanation, and should the number be unusually large an investigation is ordered.

Training of Booking Clerks. Booking clerks, as a rule, begin to learn their duties as boy clerks or boy ticket sorters. Promotion in this branch of the service depends entirely upon intelligence and merit. A smart clerk knows the geography of his line backwards, so to speak, has hundreds of fares in his head, and is a lightning calculator of ticket sums. Another important qualification for a booking clerk is an unruffled temper. Pertinacious inquirers about subjects which have no concern with the issue of tickets have to be persuaded to move on, and no notice must be taken of the remarks of irritable or ill-conditioned travellers who air grievances against the company on the "man behind the pigeon hole." Booking clerks are sometimes accused of being curt, but the fact is that they are generally working against time.

To ease the labours of booking clerks during the "rush" hours, automatic ticket-issuing machines have been adopted by the Great Western, North London, and Metropolitan Companies. These machines are, however, practically confined to the issue of workmen's tickets, at penny or twopenny fares.

Ticket Nipping. There is a good deal more in the nipping of tickets by examiners than meets the eye. The practice has a two fold object—to deface the cards so that they shall not be used over again, and to mark them by impressing a number or punching out a sign or letter, in order to afford evidence of the right of companies to claim a proportion of the through fare when passengers have travelled by a route different from that for which the tickets were issued, or to prove how far a passenger had travelled in the case of a refund claim. A different number or mark is fixed by the Clearing House for each junction or principal station, or group of minor stations, a record of the same being kept there. Further, certain numbers are kept in reserve, and given to stations from time to time as required.

Continued

THE JOURNALIST'S SYSTEM

The Journalist's Plan of Life. Building up a Library. "Every Journalist His Own British Museum." Newspaper Cuttings and What to Do with Them

Continued from page 4675

By ARTHUR MEE

IF it has seemed that these articles are inspired by an extravagant optimism, that, fortunately, cannot be helped. The road to success in journalism may be hard at times, but there are few careers which, in the main, fall in more pleasant places. And it is a fact of immense encouragement to the young journalist to know that all his life, whoever he is, wherever he may be, in whatever work he may be engaged, he can be laying the road along which to travel to his destination. He may order his life so that he is going constantly forward; slower than he will like sometimes, perhaps, but always forward. For, as we have agreed that journalism is the reflection and interpretation of life itself, it follows that the natural life of man is the journalist's best training ground. And the journalist, if he is a journalist indeed and not merely in name, so orders his life that, almost without knowing it, without any physical strain and with hardly any conscious effort, he builds up a system that becomes to him a means of living and a joy for ever.

The journalist's system is, if anything can be, his guarantee of success. No journalist can hope to succeed, in the sense in which we speak of success here, unless he has a system. What, then, is the journalist's system ?

The Organisation of Knowledge. It is, in a word, a plan of life by which all his pleasures, all his interests, all his holidays, all his books, every thought and energy he has, registers itself in his work. The chief end of the journalist's system is the organisation of knowledge and information. His motto is to have all the facts in the world on his desk. His first business is to know as much as he can himself; his next business is to be able to find out at once what he does not know. He must have a British Museum of his own. He must make his own encyclopædia from day to day. He must be able to answer any one of a million questions, and to answer them, not in a week or in a day, but in an hour or in a minute. He must be able to quote an opinion, tell a story, or recall an event, and to do all these things without leaving his own room.

If it is said that all this is impossible, that no journalist has the time to do it or can afford to do it, the reply to the critic is that he had better give up journalism. If reading is not as interesting to him as playing billiards, if books are not as much worth buying as cigarettes, he should play billiards and smoke cigarettes and leave the serious things of the world alone. We are asking nothing that has not been done, nothing that is not easy to the man who is a journalist because he loves journalism. In no age since printing began have books been more plentiful; in no country where books have been introduced have books been cheaper than in England now. Never have the newspapers been so good, so full, so varied. Never has science been so interesting, so popular, so simple. Never have commerce and industry and invention been so wonderful, so full of romance. All the strange story of the world as it moves, all the energies of the race as it reaches out to its great destiny, all the thoughts of men and all the mysteries and problems of our lives, come to us in papers and books. To say that we know nothing of these things is to declare ourselves uneducated; to say that we cannot keep a record of these things is to declare ourselves unfit for journalism.

The Legacy of Odd Moments. This course of journalism is being concluded in a journalist's library which its possessor would not part with for a gold mine in Johannesburg. It has been built up in ten years of a busy journalist's life, in leisure hours and odd moments. It has five thousand books, half of them found in second-hand book shops and in second-hand catalogues, covering every subject under the sun. It contains a record of everybody of importance who has ever lived. It contains a history of every country that has ever been. It has within its four walls the best thoughts of the best thinkers of all ages. It is a temple of all that was permanent in the past, of all the hopes of men for the future.

And, not least in value for the journalist, it is a record and an index of the present. For it is more than a library of books ; it is a library of information that never has been and never will be contained in books. It has a cabinet of a quarter of a million articles, paragraphs, notes, and references, taken from magazines, newspapers, and books. It is an ever-ready, ever-growing, ever-up-to-date encyclopædia of newspaper information, every item of it immediately accessible. At least five thousand columns of London daily papers have been written from this library. For years it furnished two regular columns a day in a well-known evening paper, and one of these columns is now running in its seventh year from this source of supply. The matter that has been supplied from this library to London editors could not be contained in all the volumes of the SELF-EDUCATOR, and the library is inexhaustible. It grows in interest and freshness every day, and the time can never come, so long as it is maintained, when a clever journalist could not earn a handsome income by sitting in this library with a typewriter in front of him, a telephone at his side, and a post office within reach.

Newspaper Cuttings. The building up of such a system of information demands no

great genius, and no very considerable outlay. It calls for great patience, care, and foresight, for an excellent sense of discrimination, and for all the qualities that go to make a journalist. It implies a capacity for organisation and persistence, and a wise utility of spare moments. It demands, above all, regularity. But these things are possible for all, and the creation of a system such as this involves no resources beyond the reach of an ordinary journalist with an ordinary income. It may mean that it is not worth while to keep a diary of social engagements, or to stand vacantly watching a football match; but success in journalism is cheap at the price.

The best of all the raw material with which the journalist has to build is the newspaper. He will find a good collection of newspaper cuttings more valuable even than books. The five thousand books in the library in which this is written might, with exceedingly great difficulty and in the course of months or years, be duplicated. But nobody else in the world has, or can have, a duplicate of the companion cabinet of information. Newspaper cuttings have, therefore, a unique value, ever increasing as the cuttings grow in quantity and variety, and the journalist who builds up his library not only of printed books, but links his books with a growing collection of *unmade books*, is building his house on a rock.

The Journalist's Newspapers. He begins by giving the newsagent a list of the papers that are most prolific in "things to cut," and he will find this experience, by the way, the surest test of whether a newspaper is well or badly done. In going through his papers he will mark everything that is to be cut, and at the end of the day he will cut these things out, date them, mark them, and put them away. He will do this every day with the dailies and every week with the weeklies, and he will never, if he is wise, allow the papers to accumulate uncut. It is a temptation to which it is easy to succumb; but it encourages carelessness and makes it impossible to rely absolutely on the system he is creating. He should at first cut out the paragraphs or articles he wants to keep and mark them afterwards: the placing of them will often be slow and difficult. In course of time, however, he will come to mark the papers before cutting them—that is, to write the index-word on the paragraph as he goes through the paper. This is much simpler, especially if he can get the papers cut for him afterwards. He must never forget to date a cutting plainly, either in the white space in the heading or on the back, and when a cutting is in two pieces it should be carefully pasted together. Small cuttings of two or three lines should be pasted on neat slips of white paper; any stationer will make a thousand slips gummed half-way down on one side for a few shillings, and these are very convenient, the ungummed portion being available for writing.

The collection may grow slowly at first, probably not at a greater rate than a dozen or twenty cuttings a day. But there is a wonderful sympathy in newspaper matter, and it is one of the amazing things in journalism how events link themselves together; how, when one remarkable thing happens, other remarkable things of the same kind follow; and after a while the rate of growth will be much greater.

Many obvious questions arise. What is to be kept? In what form should it be preserved? How is it to be marked? They are vital questions, and upon the care exercised in these directions the usefulness of the system depends.

Useless Material. What should be kept? Two things should not be kept. It is unnecessary and wasteful to store in the cabinet a great mass of information which is readily accessible in year books and encyclopædias. Twenty paragraphs may appear in the course of a year containing the barest facts of, say, Lord Rosebery's life, but as these are obtainable in a moment from a dozen familiar sources it would be waste of time and space to keep them. The second class of matter that should not be preserved is that of a fleeting and trivial kind. The great mass of matter appearing in newspapers is interesting only for a day or two and is not worth keeping under any circumstances. It may happen that for some reason or other this matter is worth cutting. Perhaps it may be helpful for a column of daily or weekly notes the journalist is writing. In that case it should be cut and kept at hand, but on no account should such ephemeral matter be admitted to the cabinet. Ordinary society and sporting information may be useful as pegs upon which to hang a piece of gossip, but when the gossip is written it is useful no longer, and it is sheer madness to choke a valuable cabinet with trivialities of this kind. It is as absurd as it would be to store flower-pots in the British Museum, and it is possible very seriously to impair the value of a system such as this by introducing matter with no permanent value, adding bulk and complexity to a system which is the more valuable the more it can be confined and the more simple it can be kept.

What to Keep from the Papers. Having decided what to leave out, the question of what to admit is easily settled. Everything of interest likely to have a permanent value should be kept. All good stories should be carefully preserved; all interesting utterances of public men; all interesting things about places. Any unusual incident, any odd fact, should be kept. Interviews, unless on some quite ephemeral topic, are usually worth keeping. The speeches of coming men, too, have a value not sufficiently realised; and the fullest report of these should be kept intact, another being cut up if worth while. Many excellent little bits of copy creep into speeches, to lie there for twenty-four hours unnoticed by most people and then to be forgotten; and the time comes when the wise journalist who has kept them reveals these little buried treasures and turns them into very gold. Articles by prominent men are generally worth

cutting up, if they do not justify preservation intact. Nearly all newspapers pay for themselves to the journalist who knows how to cut them—some sixty, some ninety, and some a hundredfold. The magazine pages of the halfpenny dailies usually provide good material for future use, and the regular columns of gossip should never be missed.

How to Keep Cuttings. In what form should the cutting be preserved? There is only one possible way. No wise journalist ever pastes cuttings into a book, or pastes them up at all. The ideal way, and the only convenient and effective way, is to place the cuttings in envelopes. The best envelopes are ordinary foolscap size, opening lengthways instead of at the end, with ungummed edges. Generally they must be specially made. When these are placed alphabetically in a drawer, with the subjects typed on the front at the top edge in the left-hand corner, with the drawers labelled, all that is necessary to put a cutting away is to open the right drawer, find the right envelope, and drop the cutting in without taking the envelope out. The cabinet should, if possible, be specially made to receive the envelopes. There are many other ways of storing cuttings, but the journalist who is beginning to build up a system of information will be wise to ignore them all and adopt this one. He will find it impossible to alter his system in a few years, and no other system is half so simple or half so effective as this.

How should the cutting be marked? This is the most important point of all. The entire value of the cabinet depends upon it. The art of indexing is not an easy one, and the placing of cuttings where they will be most useful, in such a way that they will be available whenever wanted, is often a task of great difficulty. It is, however, strange to note how often, in marking a cutting, the keyword is easily found in the cutting itself, usually in the heading or at the beginning of the article. In this case it is better merely to underline the word in ink. All marks on cuttings should, of course, be made in ink and not in pencil.

How to Mark a Cutting. Two factors should be borne in mind. There may be a dozen points of view from which a paragraph may be regarded, and the point of view from which we decide to regard it should be that which is likely to make the paragraph most useful. It will frequently be necessary to cut two or three copies of a paragraph and place them from two or three points of view, or to make cross-references; and either of these ways is easy, nearly all interesting paragraphs appearing in some form in most papers.

Another factor to bear in mind in placing a cutting is memory. When the time comes for referring to the cutting the probability is that it will come to mind, but it is essential that the headings under which the cuttings are placed in the index shall be of such a character as to help memory. Let us take an example. A woman had a delusion that she had swallowed a lizard, and the doctor, knowing her story to be absurd, placed her under chloroform and assured her that the operation had been successful. The woman "recovered," and was perfectly sane again. Obviously the paragraph is of great interest and is likely to be useful. What shall we do with it? It could be placed under LIZARDS, but that would be the wildest thing to do. It has nothing to do with lizards, except by the merest chance, and it is as likely as not that when the paragraph comes to mind we shall think of newts or cockroaches instead of lizards. *The lizard has nothing to do with the story.* The paragraph, again, could be placed under DOCTORS, but it is not really of any considerable interest from the doctor's point of view, and in writing any conceivable thing about doctors it would not greatly help one to be able to quote this example. It may, however, be contended that at least a cross-reference to this story might be made under DOCTORS. A third way in which the story might be placed is under DELUSIONS, but here again the last remark applies. In the history of delusions this woman's was not by any means remarkable.

The Classifying of Information. What, then, shall we do with it? Let us read the paragraph again and discover its fundamental idea. Clearly, it is a remarkable example of the power of imagination. It is by far the most interesting point of view from which the story can be regarded, and the power of imagination is a subject upon which a journalist can write frequently without becoming monotonous. So that we mark our paragraph IMAGINATION, date it, and put it away.

It may be, however, that the single word IMAGINATION is inadequate. Let us suppose that the journalist is greatly attracted to this subject, and collects so much material concerning it that he must classify it into subdivisions. In that case he may have such entries as IMAGINATION simply; IMAGINATION—POWER OF; IMAGINATION—STORIES. The paragraph we are considering would then come under IMAGINATION—POWER OF. This subdivision will become a matter of great importance as the collection grows. As material under a specific heading accumulates it must be edited and arranged in several groups. No single envelope must be allowed to become bulky. The more bulky an envelope is, the more difficult reference to it becomes, and the first essential of the system—instant reference—is defeated. Important general headings, such as PARLIAMENT, LONDON, GOVERNMENT, RAILWAYS, and so on, and important names in the personal section, may demand a dozen or even twenty or thirty envelopes, and it will be necessary sometimes to subdivide these divisions. Let us take an example.

To Make Reference Easy. There must, of course, be a main heading for LONDON, and one of the subdivisions will be LONDON—TRAFFIC. But the London traffic question is so important that it has several aspects, and these must be kept clearly in mind. There must be, for instance, traffic statistics, traffic

problems, traffic systems, traffic reports, traffic finance, perhaps traffic stories, and so on, and at any time the journalist may want material upon any of these specific subjects. Obviously it would be an absurd waste of time to go through the entire mass of material on the traffic question to find out how the tube railways are ventilated, and the only possible way of arranging all this matter is to have separate envelopes. The best way of marking these envelopes is to type the heading at the top left-hand corner, close to the edge, in this way:

London
Traffic

Further subdivisions should be typed like this:

London
Traffic—Statistics

These envelopes will come alphabetically in the London section of the cabinet.

The journalist will find it extremely useful and most interesting to develop his own ideas in his cabinet, and to make it much more than a record of fact. He may have, for example, some ideas as to the quickest ways to get across London, and if he will keep the idea in his mind he will find that material for its expansion will come from many unexpected sources. He should, in this case, type an envelope:

London
Quickest Ways Across

in which material for an article may gradually accumulate. In his notebook he will note "Quickest Ways Across London" as an idea for an article, with a reference to the envelope, and when he comes to write it he will find that the material he wants is ready for him.

Cutting Envelopes. The subdivision of subjects will suggest itself as the collection grows, but it may be helpful to give one instance. Let us take one subject from the cabinet mentioned. The cross-references on the outside of the envelopes should be noted. They are important, and should be typed along the top edge of the envelope in line with the heading, but at the other end.

Legal see also Verdicts, Witnesses, Judges, Police, Juries, Peasenhall Case, Inquests, Time—Legal, Fortunes, Identity, Justice—Miscarriages of, Death—Legal.

[Each subsequent envelope bears the heading Legal, but for brevity only sub-headings are given here.]

Decisions	see also Verdicts
Sentences and Judgments	
Delays	
Errors	see also Justice—Miscarriages
Illegalities	see also Govt.—Illegalities
Law Officers	
Litigants	see also Delusions
£ s. d.	see also Law Courts
Mechanical Oddities—Writs, etc.	
New Law Oddities	see also Change
Notables in Court	see also Witnesses
Oddities—Criminal	see Juries—Identity
Oddities—General	
Points	see also Time—Legal
Scandals	

The heading under which a cutting is to be placed should be clearly marked in a white space, anywhere on the cutting, rather than across the reading matter, and it is wise to use a rubber stamp for dating. It is best to mark the cuttings in the white space at the heading; in the case of cuttings which fold up this must be so, and they should be folded with the mark outside.

Personal Information. The cabinet as a whole must be divided into two main sections—personal and general. Nearly all the difficulties will arise in the general section. The titles for the envelopes in the personal section are fixed, and will determine themselves, but, to begin with, the journalist should type envelopes bearing the names of all well-known people, and in some cases several envelopes for one person, such as:

John Morley Speeches	John Morley Literature

and so on. He should also type a series of envelopes bearing all the familiar names, such as Smith, Jones, Brown. Into these envelopes all the Smiths, Joneses and Browns can go, unless in any case the Smith, Jones or Brown is important enough for an envelope to himself.

The envelopes bearing common names should in all cases be placed *after* particular names—that is, Sir William Brown should come before Brown. In putting away cuttings, this arrangement makes it clear whether Sir William Brown has an envelope of his own before the common Brown envelope is reached.

The number of envelopes bearing common names will be small, and the great mass of the personal envelopes will at first be marked with only the initial letters of names, arranged so as to receive every name that could occur. The journalist who is in earnest in building up his cabinet will be wise in carrying out his "splitting up" of the alphabet on these envelopes to the third letter. He will find that by doing this he will use some hundreds of envelopes, many of which will be empty for a long time, but in the end it will save him the trouble of having to rearrange his envelopes—a task so overwhelming that he cannot possibly afford to contemplate it. The envelopes in the personal section will begin something like this:

Aba	Aberdeen, Lord and Lady
Abadie	Abl
Abb	Sir Wm. Abney
Edwin Abbey, R.A.	Abn
Abbey	Abr
Dr. Lyman Abbott	Wm. Abraham, M.P.
Sir Jos. Abbott	Abs
Abc	Abyssinia: Emperor of
Abd	Abyssinia: Royalties
Abe	Abyssinia: Ras Makunnen
Abeokuta, Alake of	Abyssinia: Notables
Abercorn, Duke of	Ac

When this arrangement is followed through the alphabet there will be no name that cannot be placed, and the journalist will then be able to store a cutting about anybody so as to be able to find it at once. He must go through these envelopes periodically, and when he finds them growing bulky he will take out all cuttings referring to one person and give that person a special envelope. As a rule, it may be considered worth while to have a special envelope if there are three cuttings under one name.

In nearly all cases in the personal section, envelopes should be marked with names. There are, however, a few desirable exceptions, as in the case of countries where the names of public men are not familiar. The German Emperor will, of course, come under GERMANY—EMPEROR, and Prince Buelow under BUELOW; Herr Bebel under BEBEL, and so on. It is not so simple, however, in Liberia or Abyssinia, where the important names are less familiar, and in these cases envelopes marked ABYSSINIA—NOTABLES, ABYSSINIA—ROYALTIES, and so on, will save much confusion and difficulty.

Index as You Read. The arrangement of the general envelopes is not so easy, and we have already considered some of its difficulties. The cuttings themselves, however, must determine these arrangements, and experience will make the matter easier as the cuttings grow. It is a safe rule not to be afraid of divisions and subdivisions, but to exercise foresight and prepare for great developments.

It must not be imagined that a cabinet is merely a receptacle for cuttings from newspapers. It must be a cabinet of general information. The cabinet we have mentioned has in it many thousands of references made from books, with jottings of interesting facts picked up in many ways and places, so that its material on any given subject may have been gathered from three main sources: (1) Magazines and newspapers, (2) books, (3) personal knowledge. No journalist should read books without making notes. He should always have by him slips on which to make notes, and should make his own indexes of books as he reads them. There are very few books with satisfactory indexes, and fewer indexes still that are satisfactory from the point of view of the journalist to whom a book is a tool. Let us dip into our cabinet again, and we find thousands of such notes as these.

WITNESS BOX
A witness afraid of dying in the box. Life of Lord RUSSELL, 145
AGE
LINKS WITH THE PAST
Witness giving evidence of events of which he had been a spectator 120 years before. Remarkable case. 1. History of YORKSHIRE, 201.
POLITICS
UNCERTAINTIES
Difficulty of predicting with certainty in politics. Cobden on the Corn Laws, DUFF, D. 247.
Recall story of Melbourne, who told Disraeli there was no chance of his being premier.
SECRETS
STATE
Lord Granville repeating Queen Victoria's words to the TIMES. 2. Paul's HISTORY of England, 215.

Such entries as these, made constantly through years of reading, add enormously to the value of the cabinet. Though the books in the library may be duplicated, it is almost impossible that entries such as these should be duplicated, and the journalist who has such things available is not likely to want for something to write about.

How to Use a Book. There is no space here to go closely into the arrangement of the library, but the journalist will, of course, have a system making each book accessible without delay. It will be noticed in the entries above that a word from the title of each book is in capital letters, an arrangement which is part of the system. In the AGE entry, for example, the printing of YORKSHIRE in capitals means that the book will be found in the topographical part of the library under "Yorkshire." In the entry under POLITICS the use of capital letters for DUFF means that the book from which the note is made, one of Sir M. Grant Duff's diaries, is under "Duff" in the biographical part of the library.

It will be clear to all that in indexing a library many references will occur which cannot conveniently come into our cabinet. It is undesirable, for instance, to have an envelope for William Pitt or for the French Revolution. There are weighty arguments against allowing the cabinet to be used for "dead" as well as living matter, and historical things should not loom large in a cabinet of subjects of contemporary interest. As far as such things may be indexed under subject headings, they may, of course, be admitted into the cabinet, but there are many matters which could only be indexed under names having no relation to any particular subject heading.

The Card Index. There is, let us say, an important anecdote of Lord Castlereagh in the CREEVEY PAPERS, and, as the CREEVEY PAPERS do not come under CASTLEREAGH on the bookshelves, it is important that this anecdote should be introduced somewhere, so that in writing of Lord Castlereagh it may not be overlooked. The best way of registering such things is by a card-index. In the library in which this is written is a card-index covering, more or less roughly, 2,000 books of biography. It does not contain a full list of the names or titles of books, because the proper arrangement of a library makes it quite unnecessary to index them. The biographical books are arranged on the shelves in the alphabetical order of names, and the index is a contents index to the books—in some cases a full index, made when reading the book, in others a rough index, made either in glancing through the book or from the index in the book. In the latter case the index is not, of course, thorough, though full enough to be helpful, and quite worth the time it took to make it. Under C in this card-index occurs the entry:

LORD CASTLEREAGH
Extremely interesting anecdote
2 CREEVEY PAPERS, p. 38

Books Within Reach. There is no room here to consider the kind of books that are most useful to the journalist, but he should have within reach all the familiar dictionaries, concordances, encyclopædias, and year books. He cannot be satisfied with the completeness of his system unless he has on his desk, or on his shelves, WHITAKER'S ALMANACK, HAZELL'S ANNUAL, the DAILY MAIL YEAR BOOK, WHO'S WHO, CHAMBERS'S BOOK OF DAYS, HAYDN'S DICTIONARY OF DATES, BARTLETT'S FAMILIAR QUOTATIONS, CHAMBERS'S DICTIONARY OF BIOGRAPHY, HARMSWORTH and CHAMBERS'S ENCYCLOPÆDIAS, the ENCYCLOPÆDIA BRITAN-

NICA, the MUNICIPAL YEAR BOOK, the LONDON MANUAL, the DICTIONARY OF NATIONAL BIOGRAPHY, ANNALS OF OUR TIME, BURKE'S PEERAGE AND LANDED GENTRY, WHITAKER'S PEERAGE, MULHALL'S STATISTICS, BREWER'S DICTIONARY OF PHRASE AND FABLE, the STATESMAN'S YEAR BOOK, the COLONIAL, INDIA, AND FOREIGN OFFICE LISTS, a full gazetteer and atlas, a good collection of guides and histories, a good dictionary, and all the poets and standard authors. That does not mean, of course, that a library without some of these may not be excellent, but the ideal library contains all these foundation books. Only a journalist constantly using them is able to appreciate adequately the great mass of good work that is done nowadays for the pure love of doing it, without any likelihood of gain. Mr. Stead's "Indexes to Periodicals," now unhappily stopped, is an example, and for such things the journalist cannot be too thankful.

A System to Build On. The journalist who builds up a system on the lines we have suggested will find many splendid corner-stones already erected for him. It is difficult to conceive the full extent of the work on which he may build. The finger-posts to knowledge in the library in which we are writing must be counted in millions—there must be, that is, millions of keys to facts. The index to the ENCYCLOPÆDIA BRITANNICA has 600,000 entries; the index to the full set of the REVIEW OF REVIEWS has 25,000 entries to the events of the last sixteen years. Another index has about 27,000 entries to the events of the Victorian era; the DICTIONARY OF NATIONAL BIOGRAPHY contains the lives of 30,000 of the most important people who have figured in our history, and 2,000,000 facts of biographical interest. A single index exists to 30,000 poems, and two others have a total of 70,000 guides to quotations from poems. The GUIDE TO THE BEST FICTION describes the contents of 4,500 books, and has an index, with 5,000 entries, to the subjects of novels. In another work are 4,500 references to speeches, lectures, and anecdotes, and another index has over 20,000 entries dealing with folk-lore. WHO'S WHO gives the biographies of 21,000 people, and the American WHO'S WHO does the same for 15,000 people on the other side of the Atlantic. CANADIAN MEN AND WOMEN, and similar books for India and South Africa, deal with people of importance in the British Empire, and a few pounds invested in a year's supply of Blue Books puts the journalist in possession of first-hand facts from every part of the world. MULHALL'S STATISTICS gives valuable information on about 8,000 subjects. HAYDN'S DICTIONARY OF DATES has several million words of concise historical information. The CONCORDANCE TO SHAKESPEARE, a woman's labour of love for sixteen years, has 300,000 entries. The RAILWAY AND COMMERCIAL GAZETTEER, also, is an excellent work from which a word of public recognition should not be withheld. With these works to build on and encourage him, no journalist need despair of being able to create a system.

Personality in System. It ought not to be necessary to emphasise the fact that the organisation of a system of this kind does not in any way interfere with the expression of personality and originality in the journalist's work, but it is said sometimes, by those who do not properly appreciate the purpose of such a system, that it is a form of trading on other people's work. Nothing could well be more absurd. Until men cease to keep books of reference no journalist need greatly trouble about criticism such as this. If we could remember everything in the world there would be no need for systems. The journalist's cabinet of information serves the purpose of a sign-post at cross-roads, of a diary on a busy man's desk, of an index in a book—that purpose and no other. It puts a man in possession of information which he has had the foresight to realise as valuable, the patience to collect, and the ability to arrange, and he is entitled to use his facts as much as any man is entitled to write any book from knowledge such as could be obtained only from other books. The journalist who creates a system such as this may be safely relied upon to maintain the honour and dignity of journalism, and not to "live upon other men's brains."

The Mission of Journalism. He may be relied upon to fulfil the great mission of journalism as Carlyle conceived it: to make some corner of the world a little hopefuller, a little wiser, manfuller, and happier. Somewhere, behind the papers we buy lightly and read quickly and throw away, is the effort of a man to do the best he can. In the top room of a newspaper office in a Midland town there sat for years, until not long ago, a man who wrote hard day after day, week after week, for a great paper with a name known all over England. Nobody knew him, his name was never printed, he sat quietly in his top room with a heap of copy at his elbow. Each night he walked two miles into his office; at two o'clock each morning he walked two miles home again, to the rooms where he lived alone with a fatherless boy who was all his care. One bitter winter midnight he reached home without his key, and such was the manner of this scribbler that he walked two miles back to his office and two miles home again rather than wake up the little fellow who must be ready to start work at six o'clock. They found him one day bending over his desk, writing his paragraphs with pain. "It is dropsy," he said. "It has come up, and up, and when it is up to here, I suppose it will be all over; but . . . don't tell Mr. ——." They took him from his desk and from his paragraphs, and the readers of the paper knew nothing of the hand that was still.

He was just a maker of papers, what we should all try to be—a journalist and a gentleman.

JOURNALISM *concluded* · *followed by* PRINTING

THE PURIFICATION OF SEWAGE

Distributing and Sprinkling Apparatus for the Bacterial Treatment of Sewage. Method of Testing Purification

continued from page 4745

By Professor HENRY ROBINSON

A PAPER on the bacterial treatment of sewage was read before the Royal Society on May 11th, 1905, by Professor Marshall Hall, F.R.S., giving the results of a long series of experiments by Dr. Chick. These were made by treating the same sewage on bacterial beds both on the "contact" and "percolating" systems, and the following conclusions deserve recording:

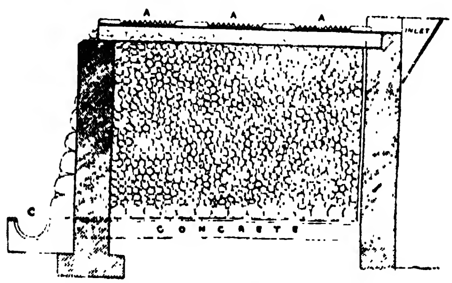
1. The advantages of the continuous method would seem to lie in the much more complete aeration and efficient diffusion, and also in the stratified distribution in the filter of the different stages of the sewage purification.

2. In the case of contact beds, however, clogging necessitates the cleaning of the whole bed, an exceedingly costly process. From these considerations, and as a result of the present experimental study, the method of continuous filtration would appear to be a most advantageous method of purifying sewage.

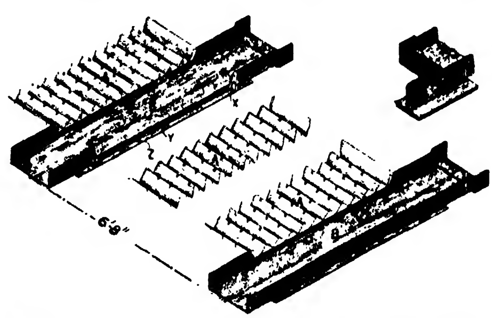
3. The contact filters did not yield nearly such good results as the continuous filters.

The depths of percolating beds must be largely governed by the level at which the sewage is discharged on to them, and at which the effluent has to be carried off; also as to the shape and level of the land to be prepared for the construction of the beds. For the purpose of comparing their working with that of double contact beds, some percolating beds have been made 9 ft. deep and even more. Experience has proved that shallow beds give as good results as double contact beds, and with a smaller area of land required, which is in many cases a most important consideration.

Purification at Various Depths. As it has been the custom of the Local Government Board to insist that the quantity of sewage discharged on to percolating beds shall be governed by the cubical contents of the bed, the surface area being reduced as the depth is increased, the following table of experiments carried out by Dr. Reid, of Stafford, are of importance as showing the purification effected at varying depths of shallow percolating beds.



42. STODDART SEWAGE FILTER

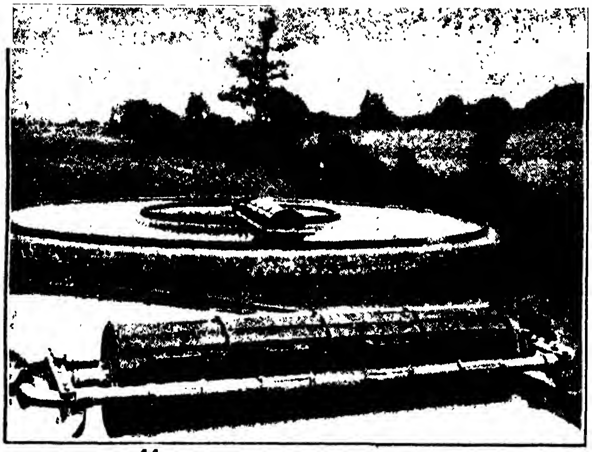


43. DETAIL OF STODDART SEWAGE DISTRIBUTOR

We shall now deal with the various methods employed to deliver the sewage to, and distribute it over the surface of, a percolating bed. As uniformity of distribution is a point to be aimed at, the writer designed an automatic arrangement [47] to regulate the flow of sewage from the outfall sewer (after the sewage had passed through a sedimentation chamber).

EXPERIMENTS IN SEWAGE PURIFICATION AT VARIOUS DEPTHS (Parts per 100,000)

Sample.	No. of Record.	Total Solids.	Solids in Suspension.	Solids in Suspension (Organic).	Solids in Suspension (Mineral).	Chlorine.	Free Ammonia.	Albuminoid Ammonia.	Oxygen absorbed in four hours at 80° F.	Oxygen absorbed in three minutes, before incubation.	Oxygen absorbed in three minutes, after incubation (3 days).	Nitric nitrogen on day of collection.	Nitric nitrogen on day after collection.	Nitrous nitrogen on day of collection.	Nitrous nitrogen on day after collection.	Column necessary to obscure test lines (inches).
Sewage ..	18	170·0	63·5	28·5	34·0	11·0	2·154	0·072	5·019	1·862	2·176	0·02	0·10	0·029	0·029	0·5
Detritus tank	13	118·1	17·0	6·8	10·1	10·0	1·643	0·486	2·726	0·975	1·095	0·02	0·09	0·014	0·022	1·6
Septic tank..	16	107·8	7·6	3·8	3·8	9·9	1·716	0·340	2·184	0·836	1·571	nil	0·09	nil	nil	1·5
Filter 1 ft. ..	16	101·5	0·25	0·16	0·08	9·4	0·036	0·052	0·328	0·093	0·067	1·64	2·07	0·003	0·003	Over 24
„ 2 ft. ..	16	101·1	0·09	0·05	0·03	9·5	0·020	0·037	0·286	0·077	0·060	1·82	1·99	0·011	0·007	„
„ 3 ft. ..	16	101·8	0·14	0·06	0·08	9·4	0·009	0·031	0·244	0·060	0·052	1·75	1·85	0·005	0·008	„
„ 4·5 ft. ..	16	103·5	—	—	—	9·5	0·043	0·027	0·259	0·070	0·039	1·70	1·99	0·005	0·002	„



44. THE FIDDIAN DISTRIBUTOR

The regulator is worked by the flow of water actuating a small water-wheel, which causes the basin to revolve. The revolving basin is provided with orifices for delivering the water into the fixed basin below, which has divisions at the bottom, each division being connected with a trough or pipe, which, according to the number of revolutions per hour, is fed with the water flowing into the revolving basin.

The regulator can be made of any convenient size or capacity, and geared to any speed desired, according to the volume to be dealt with, and distributed into the different pipes or channels to give a supply of water for any period and to any number of places or areas.

The Candy-Whittaker Sprinkler. The distribution of sewage over percolating beds by this apparatus is effected by utilising the principle of the jet. Fig. 46 shows one in position.

The sewage is delivered from below into a fixed vertical hollow standard, which projects above the surface of the bed; from this is hung a central basin or cylinder to which the arms are attached, and which are perforated down one side. The sewage issues from the perforations under a head of about 6 in., and, owing to the special construction of the bearings, this is sufficient to make the sprinkler rotate. The ends of these arms are supported by means of tie rods fixed to the central column.

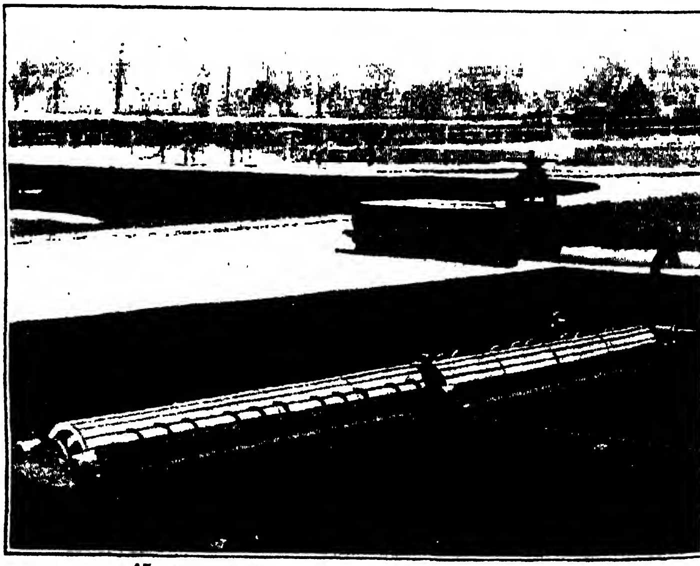
A special device is provided by which the sprinkler can deal automatically with a flow of sewage varying very considerably in quantity. This is accomplished by providing one set of arms to deal with the minimum flow, and another set to deal with the maximum, the latter coming automatically into operation after the first-named are working at their full capacity.

For large beds, exceeding, say, 80 ft. in diameter, the company make a special *buoyant sprinkler* in which the whole weight of the moving parts is supported by a buoy floating in a chamber of water at the centre of the bed. The sprinkler is made for beds varying in size from 15 ft. to 200 ft. in diameter.

AVERAGE RESULTS OF WILCOX & RAIKES' DISTRIBUTOR.

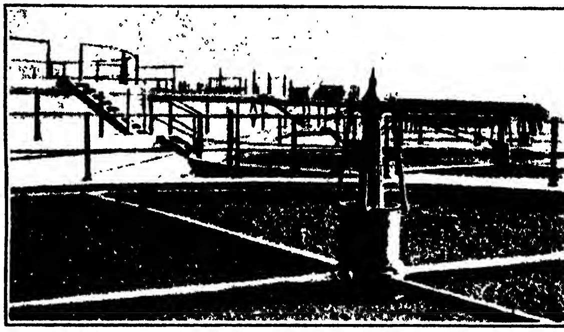
Sample of	Solid: In Solution.	Solid: In Suspension.	Solid: Total.	Chlorine	Free Ammonia.	Organic Ammonia.	Oxygen absorbed in four hours at 80° F.	Nitric Nitrogen.	Column necessary to obscure test lines, inches.
Sewage	129·8	58·9	188·7	8·6	2·009	0·709	3·814	0·04	0·79
Septic tank effluent ..	101·0	3·9	104·9	8·8	1·891	0·280	1·851	0·11	1·8
Rectangular filter (fine portion)..	105·6	0·6	106·2	8·5	0·233	0·035	0·327	1·55	over 2 ft.
Rectangular filter (coarse portion)	97·9	0·3	106·0	8·4	0·268	0·039	0·339	1·50	over 2 ft.

The Stoddart Sewage Distributor. This is a form of distributor on the percolating principle, and has been successfully used at the



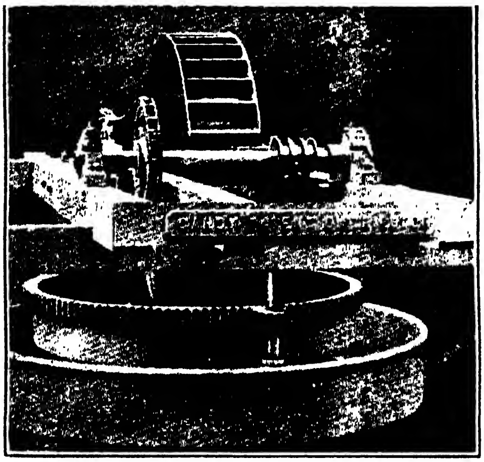
45. THE HAM-BAKER AUTOMATIC DISTRIBUTOR

outfall works of the Horfield Urban District Council, Bristol, where experiments were carried out. Fig. 42 shows the filter with the distributor on the top at A and the collecting channel C at the bottom. Fig. 43 shows the special arrangement of the distributor in detail. The distributor A receives the sewage from the supply channel B. The recesses to receive the distributor are shown at X, Y, and Z. The principle on which the distributor acts is as follows. The liquid is brought into a gutter, overflows the margins provided with diamond-shaped holes, and on reaching the under surface it meets with a series of drip points, from which it drops upon the filter.



46. CANDY-WHITTAKER REVOLVING SPRINKLER

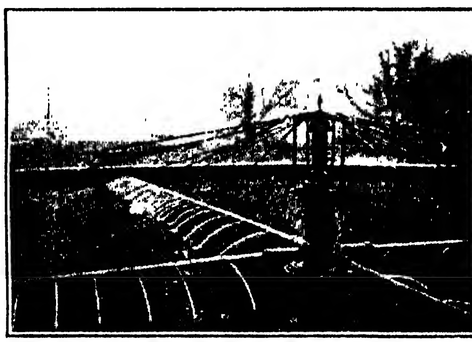
Wilcox and Raikes Distributor. Another distributor is known as the Wilcox and Raikes [49], and has been used at the



47. AUTOMATIC DISTRIBUTOR

Hanley outfall works. This arrangement consists of a trough, carried on tram lines, running up the two sides of a rectangular filter. The trough is propelled by an electric motor, the sewage overflows on to one half of the filter while the trough is travelling in one direction, and on to the other half of the filter while it is travelling in the opposite direction. The effluent from the septic tank at Hanley, which yielded 0·28 parts per 100,000 of albuminoid ammonia, was distributed over a filter of saggers 4 ft. 6 in. deep, the material of which was between $\frac{1}{4}$ in. and $\frac{1}{2}$ in. in size. The effluent from the filter contained about 0·025 of albuminoid ammonia, and 1·5 of nitrogen as nitrates; the purification effected, as measured by the reduction of albuminoid ammonia, was over 91 per cent.

Other Rotary Distributors. Fig. 44 shows the Fiddian distributor, which consists of an elongated water-wheel of from 9 in. to 18 in. diameter, moving in a horizontal plane, fed from a tubular radial arm which encircles it, and connects it to the vertical centre stand-pipe through which the sewage is delivered from the tank.



48. ADAM'S REVOLVING SPRAY DISTRIBUTOR

The water-wheel is made to travel around the bed on wheels at its ends by the sewage falling into the buckets of the water-wheel a little above the level of its axis. The weight of the water in the bucket is the motive power. As the buckets approach the surface of the bed the contents are delivered thereon in fine films, and as they rise dripping, they form a spray, thus sprinkling the sewage for the whole width of the wheel at each revolution, and aerating it.

Fig. 45 shows an automatic distributor

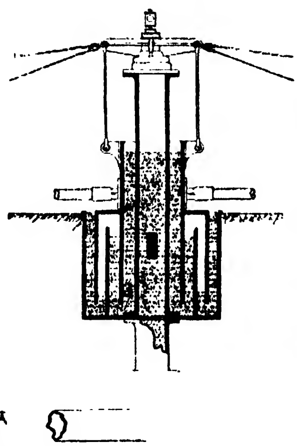
49. THE WILCOX AND RAIKES DISTRIBUTOR

(made by Ham, Baker & Co.) for rectangular sewage filter beds.

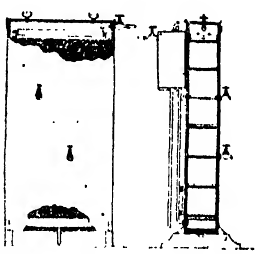
The revolving distributor made by Messrs Ham, Baker & Co. is shown in **52**.

The sewage is conducted to the distributor by means of a horizontal cast-iron pipe, A, and issues from the central pillar, B, through fixed pipes, C, into a trough, D, fitted with distributing pipes, E. The trough and pipes are connected by means of steel suspension rods, F, to a head of cast iron, G, that rests on the top of the pillar, B, and is provided with ball bearings, H, suitably lubricated to allow the distribution to revolve freely on the fixed pillar. This distributor has been designed with the object of obtaining the full advantage of the initial head of sewage, in order to start the rotary motion, and this is effected by the incoming sewage striking upon blades J, fixed on the central trough, and it is continued by the sewage issuing from the distributing pipes, and being sprinkled on to the filter bed. The distributing pipes, E, have sparge holes, K, spaced to give an equal distribution to the sewage over the whole area of the bed.

Fig. 48 shows an Adam's Revolving Spray Distributor applied to a percolating bed. The construction and working of this apparatus is shown in **51**.

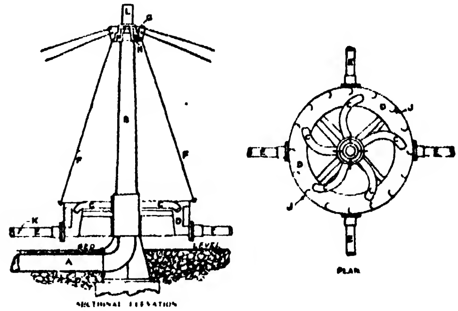


51. SECTION OF FIG. **48**



50. THE SCOTT-MONCRIEFF TESTING APPARATUS

Testing Apparatus. Mr. W. D. Scott-Moncrieff has devoted much time and care to study the best conditions under which sewage or polluted water can be purified in filters by the intelligent utilisation of the micro-organisms which nature develops in them, so as to ensure the organisms working under favourable circumstances and environment. This involves the adoption of means to prevent the development of fibrous and gelatinous growths which are inimical to the changes which the bacteria can effect, and which at the same time choke up and diminish the efficiency of the filter. To prevent the formation of these growths, or to cause their disappearance if they have formed, oxidation is essential either by resting the filter or by regulating the amount of fluid that is passed through it. After many experiments Mr. Scott-Moncrieff devised an apparatus [**50**]. The object of it is to enable information to be obtained as to the best depth for the filtering material, and the amount of air required to oxidise any particular sewage. The sewage is discharged on to the top layer of filtering medium by means of a tipper which is fed by a regulating tap. This tipper can be adjusted to regulate the rates of flow and discharge.



52. THE HAM-BAKER REVOLVING DISTRIBUTOR

The unit of surface adopted in this apparatus is 3 sq. ft., as it is considered that this ensures a practicable arrangement for the measurement of the air, and a sufficient flow of sewage to be capable of accurate regulation. A shallow box, 1 ft. square, is placed upon any part of the filter bed to be dealt with. If the distribution of the sewage over the bed is at the rate of 1,000,000 gallons per acre in 24 hours, the apparatus must discharge into the box one pint eight times an hour. This box and a pint pot are all that is required to enable accuracy of distribution to be tested. The depth of the filter represented by the apparatus is taken at 6 ft., so that there will be a unit of 18 cubic ft. of filtering material with 3 sq. ft. surface.

Samples of the fluid passing through the apparatus can be taken from the taps as shown. They are fixed in echelon so that samples can be drawn off simultaneously for every foot from one to six.

By employing this apparatus it is claimed that the depth of filter needed for any required standard of purity can be determined by simultaneous analyses from all the sampling taps. The rate of air supply, of the flow of the liquid, and the periods between the discharges, can be noted, and plotted on a diagram, from which conclusions can be deduced to determine the four principal factors—namely:

(*a*) The depth of filter required to produce the necessary standard of purity in the effluent.

(*b*) The quantity of air necessary for the life processes of the organisms.

(*c*) The proper rate of flow per unit of filter-bed surface in order to obtain the best results.

(*d*) The best period of rest between each discharge to prevent gelatinous growths in the filtering material.

SEWERAGE *concluded; followed by* REFUSE DESTRUCTION

WOMAN'S PLACE IN THE WORLD

Woman and the Survival Value of Societies. How Society Would Disappear in One Generation. What Woman May Gain and What She May Lose

Continued from page 4667

By Dr. C. W. SALEEBY

CLOSELY allied to the study of the fundamental social institution of marriage is that of the place and functions of women in society.

Past sociological theory has shown two extremes in its analysis of this question, while the more modern view is that the truth lies somewhere between these extremes. On the one hand we have what may be called the theory of *matriarchy*, which we owe to the sociologist Bachofen. Arguing from the known fact that among certain contemporary peoples descent is often traced through the mother alone, this thinker inferred that at one stage in the past societies were dominated by women, as the word matriarchy suggests. In this theory he is supported at the present day only by Dr. Lester Ward, the distinguished American sociologist. We have not room here for a full discussion of this subject. We can only say that contemporary sociological opinion has condemned the matriarchal theory—a theory which certainly seems contrary to all probability and experience.

The Saddest Thing in History. At the other extreme is the view that in the earliest and rudest communities the place of woman was hopelessly degraded; that she did all the drudgery, and was regarded by primitive man as little better than a beast of burden. It seems true that the subjection of woman has been less extreme than some have supposed, but we may here quote three classical expressions of the older view. In his "Descent of Man" Darwin says: "Man is more powerful in body and mind than woman, and in the savage state he keeps her in a far more abject state of bondage than does the male of any other animal." Letourneau says: "Almost at the origin of human society woman was subjugated by her companion. We have seen her become in succession beast of burden, slave, minor, subject, held aloof from a free and active life, often maltreated, oppressed, punished with fury for acts that her male owner would commit with impunity before her eyes." Lastly, we may quote from Herbert Spencer's "Principles of Ethics":

"In the history of humanity as written the saddest part concerns the treatment of women; and had we before us its unwritten history we should find this part still sadder. I say the saddest part because, though there have been many things more conspicuously dreadful—cannibalism, the torturings of prisoners, the sacrificings of victims to ghosts and gods—these have been but occasional; whereas the brutal treatment of woman has been universal and constant. If, looking first at their state of subjection among the semi-civilised, we pass to the uncivilised and observe the lives of hardships borne by nearly all of them—if we then think what must have gone on among those still ruder peoples, who for so many thousands of years roamed over the uncultivated earth, we shall infer that the amount of suffering which has been, and is, borne by women is utterly beyond imagination. . . . Utter absence of sympathy made it inevitable that women should suffer from the egoism of men, without any limit save their ability to bear the entailed hardships. Passing this limit, the ill-treatment, by rendering the women incapable of rearing a due number of children, brought about disappearance of the tribe; and we may safely assume that multitudes of tribes disappeared from this cause, leaving behind those in which the ill-treatment was less extreme."

Man's Abuse of Power. On this Dr. Lester Ward remarks that he must protest against the term brutal, "since, as has been seen, no male brute maltreats the female, and the abuse of females by males is an exclusively human virtue."

Professor Westermarck, however, has lately made an exhaustive study of this subject, and he has shown that while it is doubtless true that the position of women among the lower races is often one of abject slavery, yet, on the whole, the position of woman has been much less degraded than earlier sociologists and popular opinion imag'ne. That is, of course, by no means to suggest for a moment that the treatment of woman in society in the past has been just. There is abundant warrant, even in the light of the most recent researches, for the fine words of the great French sociologist Condorcet:

"Among the advances of the human mind most important for the general welfare we should number the entire destruction of the prejudices which have produced between the sexes an inequality of rights injurious even to the favoured sex. In vain is it sought to justify it by differences in their physical organisation, in the strength of their intellects, in their moral sensibilities. This inequality has had no other origin than the abuse of power, and it is in vain that men have since sought to excuse it by sophisms."

The Injustice of the Church towards Woman. Whereas it is the tendency of the highest forms of religion to elevate the status of woman, it is the lamentable truth that most of the prominent religions of the world have had a tendency to treat women as inferior beings. Unfortunately, the Early Christian Fathers concurred in this view, many of them holding that woman did not possess a soul. Few more horrible and disgusting things have been said about woman than stand to the record of some

of these writers. Woman has been in all ages the great upholder of religion, but it has done her little temporal service.

On the other hand, we may point the immeasurable contrast between the corruptions of Christianity and the first and supreme assertion of justice to woman that is to be found in the 8th chapter of St. John: "He that is without sin among you, let him first cast a stone at her." Here we have expressed in the teaching of the Founder of Christianity the doctrine which Christianity itself, like other religions, has unfortunately failed to live up to, but to which in this age we are slowly approaching—the doctrine that the code of justice and of morality can make no distinction in man's favour as against woman. The study of English law shows that we are still far from realising this ideal, but we are beginning to offer it formal recognition.

We must now leave the historical aspect of this question, but in doing so we would remind the reader of the extreme significance which is to be attached to the last sentence of our quotation from Herbert Spencer. It is there suggested that when the condition of woman becomes too hard, rendering her unfit for her supreme function, the society in which this occurs must disappear. Here, again, in another form, is an assertion of the principle of *survival-value*, which we invoked in our study of marriage and its various forms. It will be well for us to look a little more closely at this principle of survival-value, one of the few fundamental principles of all sociological theory.

The Right to Live. If we survey the whole world of living things merely as individuals, we discover that everything that lives lives because it can. Nature knows no other right than might, and until we enter the moral sphere of civilised human life we find that the right to live depends upon the might to live. Now, all living species, animal or vegetable, tend, in anything like favourable circumstances, to multiply, and as the supply of food and standing room, though large, is finite, it follows that of the new generation of any species the fittest tend to survive—Nature selects them. This is the great biological principle that Darwin called Natural Selection, and which he adduced in explanation of organic evolution. As he himself recognised, the term is not satisfactory, since it suggests an active choice on the part of Nature, and since it does not explain the principle of survival. Herbert Spencer introduced the term "Survival of the Fittest," which Darwin was glad to insert in the second edition of "The Origin of Species." The rule, then, is that the fittest survive, and they do so in virtue of characters that have survival-value. In the tiger these are teeth and claws; in the horse, strong muscles and a tough stomach; in the bird, feathers; in the microbe, poisons or toxins; in the oak, a waterproof coat and green leaves.

But what is true of the individuals of any race or species is also true of any species as against any other species, or of any society as against any other society. The principle of natural selection prevails here. In studying the characters of any society, therefore, we have to recognise that the social organism, like the individual organism, depends upon its might for its right to live, and its might depends upon the possession of characters that have sufficient survival-value, both from the point of view of the contest of society against the conditions of its environment, and its contest with societies around it. Just as the fundamental principle of individual evolution or organic evolution has been this principle of an automatic process by which the fittest survive, so also this has been the fundamental principle of social evolution and of the evolution of social institutions.

The Value of Woman to Society. Every competitor for existence or for persistence as a character of living things, or societies of living things, has to pass through the ordeal of natural selection. We saw how the dominant form of marriage has succeeded in being dominant, despite its lack of attractiveness to a very large proportion of men, simply because it has supreme survival-value for the society in which it flourishes, and because societies in which other forms of marriage prevailed have proved less *fit*. Thus we have a simple but universally applicable criterion by which we should be enabled to judge of any social character or institution, and in considering the woman question we must not lose sight of this principle.

Suppose, for the sake of argument, that women, as a whole, desired to devote their lives to the same activities as men; suppose, also, that in doing so they achieved great personal happiness and the utmost success; suppose that they added incredibly to material wealth, to invention, scientific discovery, and art, and more than proved their title to rank as the equals of man in these respects. From the point of view of the individual, such activities would be justified; but our business is to hold fast to the fundamental truths of biology, and therefore, as sociologists, we should be compelled to condemn without any qualification such a prospect. Magnificent though these achievements might be, they would have no survival-value for the society that displayed them, *for where would the babies come from?* Such a society, though wealthy, learned, cultured, would utterly disappear in one generation. Its place would be taken by some savage horde, the women of which were *mothers*, and in a few years all its store of learning and art would utterly disappear. Its civilisation would have stultified itself. This, of course, is all perfectly self-evident, and yet sometimes it is the most self-evident truths that are the most forgotten. Now, having firmly grasped our first principles, let us turn to the question of woman's place in society to-day.

The First Condition of Survival. The first condition of the survival of any race or society is evidently that its individuals shall be capable of leaving descendants to establish the continuity which is the meaning of survival. Now, it is a permanent and ultimate fact of biology that woman's part in this function is necessary and difficult. In fact, we have to face in the case of every woman—assuming that she

does the work for which Nature intended her—an "antagonism between individuation and genesis." This phrase was used by Spencer in elucidating his wonderful discovery of the law of multiplication in living things. The phrase simply means that since the total stock of energy possessed by any individual is finite, if that individual spends all its energy upon its own development or individuation, it will leave none for reproduction or genesis. Whereas, on the other hand, if it devotes all its energy to genesis, as microbes do, none will be left for its own individuation. Now, in the case of man the biological aspect of this antagonism has been extremely simplified. The facts are such that scarcely any appreciable expenditure of energy is required from him for any but the purpose of individuation. He is free to expend practically his whole physiological income upon himself; there are no other claims which interfere appreciably with the claims of his individual business in life, whatever that may be.

The Output of Human Energy. But when we consider the case of woman we find that this "antagonism between individuation and genesis" becomes acute and critical. We find also that the female organism normally shows a definitely different tendency to that of the male organism. Woman's actual output of physical energy is definitely less than that of man in the proportion of about five to eight. But there are two kinds of energy, potential and kinetic; and this estimate is concerned only with kinetic energy—the energy of movement and action. It is the peculiar character of the female organism that it tends towards the accumulation of potential energy rather than towards the output of kinetic energy. Biologists speak of the chemical functions of the body as *metabolism.* Those which involve the breaking down or analysis of complex chemical compounds with the liberation of kinetic energy are described as *katabolism*; while those processes which tend towards the accumulation of potential energy in the form of complex compounds—processes more extensively illustrated in the vegetable than in the animal—are described as *anabolism.* This distinction has already been discussed in the course on Chemistry.

The "Gain and Loss" Account. Now, it is a demonstrable fact that the female organism is, on the whole, *anabolic* rather than *katabolic* in tendency, as was brilliantly proved by Professors Geddes and Thompson in their famous book "The Evolution of Sex." They summarise their main proposition as follows:

"In all living creatures there are two great lines of variation, primarily determined by the very nature of protoplasmic change (metabolism); for the ratio of the constructive (anabolic) changes to the disruptive (katabolic) ones—that is, of income to outlay, of gains to losses—is a variable one. In one sex, the female, the balance of debtor and creditor is the more favourable one; the anabolic processes tend to preponderate, and this profit may be at first devoted to growth, but later towards offspring, of which she hence can afford to bear the larger share. To put it more precisely, the life ratio of anabolic to katabolic changes, $\frac{A}{K}$, in the female is normally greater than the corresponding life ratio, $\frac{a}{k}$, in the male. This, for us, is the fundamental, the physiological, the constitutional difference between the sexes; and it becomes expressed from the very outset in the contrast between their essential reproductive elements, and may be traced on into the more superficial secondary sexual characters."

A Definite Limit to Woman's Activity. Therefore, if woman is to continue to discharge those anabolic functions, consisting in the accumulation of potential energy for her unborn children, or the provision of their nutriment after birth, upon which the continuance of the race depends, there is a definite and necessary limit set to her external activities—to that output of kinetic energy which depends upon what the physiologist calls katabolism. She cannot both eat her cake and have it; cannot both accumulate energy for the racial life and expend it for her individual life. Suppose, for the sake of argument, that man and woman have each one hundred units of energy to utilise. Man, who does not bear the brunt of the reproductive function, can afford to spend his energy on external activities. Woman may spend all her energy similarly, and may successfully compete with man as an economic unit; but, if she does so, she will have no energy left for the supremely important function which she, and none other, can discharge. *If woman is to continue to be woman she cannot compete on equal terms with man so far as external activities are concerned.* If she attempts to become man and woman too, she is apt to end by failing to be either. But if woman does not continue to be woman, there is an end of human history, the resources of science notwithstanding.

The Supreme Function in Life. The problem for woman, then, is to expend her finite stock of energy so as to discharge without mutual injury both her duty to the race and her duty to herself. It is true that she can enter into economic competition with man, but in so doing she is bound to neglect her duty to the race. This is conspicuously true of the married woman who is also a wage-earner. As the present writer has said elsewhere, she spends all her physiological capital for that which is not bread; and there is none left to endow her children, born or unborn. Our criterion of survival-value will enable us to recognise that, in declaring an economic equality of the sexes to be unattainable, we are not decrying but are exalting woman's value to society. Her characteristic powers are not of economic value in the narrow and stupid sense of that term; but, on the other hand, since these characteristic powers of hers are absolutely indispensable to society, it will be evident that the conservation of them in the fullest degree is the conservation of a factor which is of supreme survival-value. It has often been said that woman lowers herself and loses her dignity by her anxiety to enter into economic competition with

man. Here, however, we are not concerned with any questions of dignity or chivalry; our business for the moment is to discover the fundamental conditions which are necessary for the continuance of any society, and the first discovery we make is that there is no male function which can rank in practical importance beside woman's functions in respect of the production, the nourishment and the upbringing of children. It is, therefore, properly speaking, a degradation of function for woman to leave this supreme work, which she alone can do, and to concern herself with lower functions which others can do. We advisedly call them lower, and the adjective is justified on every ground.

Women's Functions are Higher than Men's. The functions which men can discharge are lower than those of woman, and, in the first place, because they are ethically inferior. Whereas man's business is essentially selfish unless he be a husband and father, the characteristic business of a woman is essentially unselfish. But man's functions are lower than woman's even from the mere standpoint of political economy. As Mr. Sidney Webb has lately said: "We may at last understand what the modern economist means when he tells us that the most valuable of the year's crops, as it is the most costly, is not the wheat harvest or the lambing, but the year's quota of adolescent young men and women enlisted in the productive service of the community; and that the due production and best possible care of this particular product is of far greater consequence to the nation than any other of its occupations." As the present writer has said elsewhere, "The only material of which empires have ever been or ever will be built is *human*. When there fails an adequate supply of such material, or when it ceases to be of the stuff of which empires are made, the fiat of doom has gone forth—the 'decline and fall' are at hand."

Economic Competition Degrades the Sexes. Experts may talk of exports of cotton or wool or what not, and may appraise by this means our Empire's life and vitality, but the state of its human produce, whether retained for home consumption or exported across the seas, is the sole valid criterion which the serious student can admit.

"Ill fares the land, to hastening ills a prey,
Where wealth accumulates and men decay."

But no finer and more convincing passage can be quoted than this from Ruskin: "In some far-away and yet undreamt-of hour, I can imagine that England may cast all thoughts of possessive wealth back to the barbaric nations among whom they first arose; and that she, as a Christian mother, may at last attain to the virtues and the treasures of a heathen one, and be able to lead forth her sons, saying, 'These are my jewels.'"

These, of course, are merely various ways of saying that the survival-value for society of the functions peculiar to women is greater than that of any functions which can be discharged by men. This assertion of the dignity and importance of motherhood is, of course, no novelty. It has been preached by poets and moralists for ages, and is certainly independent of the assertions of any science; but the fact remains that it can be verified on purely biological grounds, and quite apart from any sentiment on the part of the sociologist. There is abundant warrant, therefore, for the assertion that the economic competition of women with men constitutes a degradation of their sex. It is true that this competition tends to make the struggle for life harder for man, and his opinion on the subject may be sometimes due to his desire to free himself from an unwelcome competitor. But it is certain that in the last resort such competition injures both sexes and society at large.

The Verdict of Physiology. Now, it is a remarkable fact that physiology records in woman's person its verdict upon this matter. The bodily or physical characters which give woman her distinctiveness and charm depend upon an adequate preponderance of anabolism in her functions. If the due balance be upset, it is found that the woman approximates to the masculine type. The change is shown in the figure and in the physiognomy. The functions characteristic of her sex are no longer discharged—this statement being true alike of the woman who devotes herself to hard, intellectual work, and the woman who devotes herself to athletics. It is a somewhat remarkable fact that the same physiological results should follow from occupations so utterly different. Their point of agreement lies in this—that they both interfere with the physiological balance of the female organism. It is to be observed, further, that the characteristic psychology of woman depends upon her womanliness, and disappears when she loses it. She may gain in the power of abstract reasoning, and in a sentiment for justice rather than mercy: but she loses in intuition, in sympathy, and in other feminine characters of mind which are of value both to the individual and to the race.

The Just Claims of Woman. The question then is, what are the just claims of woman—that is to say, claims the granting of which is compatible with her womanliness and with the preservation of that survival-value which depends upon it? The very last thing which may rightly be inferred from what we have said is that it is woman's duty to give herself up exclusively to the reproductive function. We desire a due balance between anabolism and katabolism—not the performance of the one to the total exclusion of the other. That any individual shall give herself up entirely to "genesis," and ignore "individuation" altogether is to reduce herself to the level of the microbe. Merely we assert that the differentiation of living organisms of the higher species into two sexes is evidently warranted by Nature, the "evolution of sex" being a biological fact which plainly must have some survival-value for every species that exhibits it; and we shall not safely flout Nature by any attempt to abolish this differentiation and make woman only a smaller variety of man.

Continued

OILS, FATS, WAXES, & CANDLES

Chemical Constitution and Industrial Treatment of Oils, Fats, and Waxes. Modern Candle Manufacture

Continued from page 1782

By JOHN McARTHUR

FIXED oils and fats are very widely distributed in the vegetable and animal kingdoms, and are present in great variety and abundant quantity. From even the earliest times man has not been slow in recognising their valuable properties, and with the advance of scientific knowledge and the improvement in mechanical appliances he has been able to extend their use, so that at the present time they form the basis of some of the most important industries of the world.

It is impossible to draw any strict dividing line between an oil and a fat, but, speaking generally, the term *oil* is applied to such glycerides as are liquid at the ordinary temperature, while the term *fat* is used to describe those which are solid. It will be readily understood, however, that as the consistency of these substances is readily susceptible to any change in temperature, a given oil which may be liquid under certain climatic conditions may become solid under others. In the same way, also, a solid fat may become a liquid oil when subjected to even a natural increase in temperature, and may also assume a "buttery" consistency intermediate between that of an oil and a fat. Many attempts have been made likewise to classify oils and fats into groups having physical or chemical properties common to each, but these attempts have not always proved successful.

Chemical Constitution. Considered chemically, oils and fats are mixtures of certain organic compounds composed of carbon, hydrogen, and oxygen, called *glycerides*, or esters of the higher fatty acids. The glycerides which form the various oils and fats are principally those of stearic, palmitic, and oleic acids, and also of other less important fatty acids such as butyric, caproic, etc. Prior to the well-known researches of Chevreul, published in 1823, fatty bodies were supposed to be simple substances.

A glyceride may be looked upon as a compound of fatty acid and glycerol or glycerin. The latter being a tri-hydric alcohol, and behaving chemically as a base, is capable of combining with three radicles of fatty acid, forming a *tri*-glyceride.

Thus:

$$\left.\begin{matrix}C_3H_5\\H_3\end{matrix}\right\}O_3 + 3(C_{18}H_{36}O_2) = \left.\begin{matrix}C_3H_5\\(C_{18}H_{35}O)_3\end{matrix}\right\}O_3 + 3H_2O,$$

glycerol stearic acid tri-stearine water

and in a similar manner, with the radicles of palmitic and oleic acids, tri-palmitin and tri-olein,

$$\left.\begin{matrix}C_3H_5\\(C_{16}H_{31}O)_3\end{matrix}\right\}O_3, \text{ and } \left.\begin{matrix}C_3H_5\\(C_{18}H_{33}O)_3\end{matrix}\right\}O_3,$$

respectively, are formed. Mono- and di-glycerides—that is, compounds containing either one or two acid radicles, can be formed synthetically, but, as a rule, the tri-glycerides only are present in fresh neutral oils and fats.

When oils and fats are heated with water under pressure, hydrolysis takes place, with formation of fatty acids and glycerol; and on treatment with alkalies an analogous reaction occurs, glycerol is also formed, and the fatty acids combine with the alkali to form *soap*.

The natural oils and fats often contain large proportions of free fatty acids, due to decomposition caused by certain natural ferments, or enzymes, present in the accompanying vegetable or animal matter, as well as small quantities of colouring, odorous, and other substances.

General Properties. As already indicated, neutral oils and fats may be liquid, "buttery," or solid at normal temperatures, but even the hardest fat becomes fluid at a temperature under 100° C., and it is not until a temperature of over 300° C. is reached that they undergo any marked change. It is for this reason that these bodies are described as *fixed*, to distinguish them from *essential* and *mineral*, or hydrocarbon, oils, which can be volatilised. At the higher temperature named above, glycerides suffer decomposition, the most characteristic product being *acrolein*, an intensely acrid body formed by the destruction of the glycerol.

The *pure* oils and fats are colourless, tasteless, and odourless, but the commercial products vary in colour from pale yellow to red and dark brown; and each generally possesses a taste and odour peculiar to itself, due to the presence of certain foreign organic substances. They are all lighter than water, the specific gravity at 15·5° C. ranging between about 0·875 and 0·9,0.

All the oils and fats are quite insoluble in water; they are soluble to a certain extent in alcohol, especially when hot, and are readily soluble in ether, carbon bisulphide, chloroform, benzene, petroleum spirit, and certain other volatile oils; castor oil, however, behaves somewhat exceptionally. They possess the property of penetrating dry substances, such as paper, textile fabrics, etc., causing these to appear transparent, and forming the well-known "greasy stain." They are not inflammable under ordinary conditions, although by means of a wick they burn readily with a bright flame. When exposed to the atmosphere, oils and fats become oxidised, acquiring a rancid taste and a disagreeable odour. This change is more marked in the case of certain "drying" oils, such as linseed and hempseed, which, when exposed in a thin layer, rapidly absorb the atmospheric oxygen, forming a solid varnish.

Methods of Production. The processes employed for obtaining oils and fats from the seed, kernel, fruit, or animal tissue in which they are contained depend largely upon the particular nature of the material to be treated and the purpose for which the product is required. Great advance has been made upon the primitive methods of earlier times, although in some countries those in use are still somewhat crude, resulting often in considerable loss of the product, and in the deterioration of its quality. By simple heating it is possible to effect the separation of much of the fatty matter contained in certain materials; but the methods generally employed depend upon the removal of the oil or fat by pressure, and by extraction by means of volatile solvents. In the case of animal products, the process of *rendering* is employed.

As a preliminary to the treatment by pressing or by solvents the seed or kernel is ground finely by passing it between powerful stone or iron rollers, or it is broken up in disintegrators.

Pressing. The hydraulic press is now employed in the most modern oil-mills, the earlier forms having been now almost entirely superseded. If the colour and taste of the oil-product have to be considered, as in the case of castor oil, or of salad oil from cottonseed, the crushed seed in the form of *meal*, is placed in bags, and pressed in the cold at a pressure of about two tons per square inch. The pressed cake still contains a considerable proportion of oil, the bulk of which is removed as a product of lower quality, to be used for manufacturing purposes by disintegrating the cake and pressing it hot.

1. EXTRACTION APPARATUS

When the maximum yield of oil is the main object in view, and the product is not required for edible purposes, the meal, which is meanwhile kept moist by steam, is heated to about 70° to 80° C. in a steam-jacketed vessel provided with a mechanical stirrer. It is delivered into a measuring box, then placed in cloths in a moulding machine, and gently pressed into shape. The cakes thus formed are then subjected to high pressure and the expressed oil collected. The cakes are removed and the oily edges trimmed off to be ground and re-pressed. The cake still contains about 10 per cent. of oil, and in the case of certain seeds is largely used as a food stuff for cattle. Fig. 2 shows the Anglo-American form of press now largely employed.

Extraction. In the process of extraction by means of solvents the agents employed are generally petroleum spirit and carbon bisulphide.

Various forms of apparatus are used for the purpose. If the extraction is carried out in the cold, the solvent is made to percolate through the ground seed contained in a series of closed vessels. Other forms are constructed on the principle of the Soxhlet apparatus [1], where a condenser is connected at *b*. These allow of continuous extraction with a reduced quantity of the solvent, which is heated. When the mass has been completely extracted, the solution is withdrawn, the solvent distilled off and condensed, to be used over again, while the extracted oil remains.

Rendering. In this process, which is applied to the *rough fats* of animal origin, whereby the tallow, lard, or other fat is separated from the tissue of nitrogenous non-fatty matter, the materials are sometimes simply exposed to dry heat, when the fatty matter melts away; but generally they are boiled with water, and subsequently with dilute sulphuric acid, when the clean fat rises to the surface and is skimmed off.

The heating of the materials with water under pressure in a digester fitted with a false bottom, as shown in **3**, is now becoming more general.

This method is the most effective, and obviates the production of the disagreeable odours which prove so objectionable in the other forms of the process.

Methods of Purification. The oil or fat, having been separated from the seed or animal tissue by one or other of the processes described, contains some water as well as albuminous or fibrous matter; for the removal of these it is generally passed through a filter-press [4], from which it flows in a bright and clear condition. The agitation of the heated oil or fat with such agents as fullers' earth and animal charcoal often effects a marked improvement in colour.

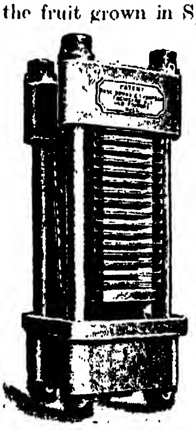
Treatment with chemicals for the removal of foreign dark-coloured substances requires to be applied with care. Agitation with from 1 to 2 per cent. of comparatively strong sulphuric acid at about 70° C. is employed with advantage in the case of such oils as rape and linseed; the foreign matters become charred, and settle out, when the clear oil can be separated and washed with warm water.

Cottonseed oil is refined by agitation with a solution of caustic soda of 1·05 to 1·10 specific gravity, at about 50° C.: the minimum quantity only is used, but sufficient to combine with the free fatty acids and the colouring matter. The decolorised oil rises to the surface and is removed and washed, while the soap and mucilage remain underneath. This process is employed also for the refining of other oils and fats, where a perfectly neutral (fatty acid free) product is required.

Bleaching by such agents as manganese dioxide and potassium bichromate, in presence of sulphuric acid, depends upon the action of the nascent oxygen formed: the use of ozone has been recommended. The bleaching of palm oil is generally effected by treatment with potassium bichromate, and hydrochloric acid, and sometimes by air.

We shall now briefly describe the origin, properties, and applications of the principal oils and fats.

Olive Oil. This oil is obtained from the fleshy part of the fruit of the olive-tree (*Olea Europæa* species) by pressing and by extraction. There are many commercial varieties of the oil. Those from Provence and Tuscany are considered the finest: other qualities are obtained from the fruit grown in Spain, Turkey, Greece, in California, and in South Australia, etc. The quality of olive oil depends upon the origin of the fruit, and other circumstances: the finest is pale yellow in colour, almost odourless, and pleasant to the taste, while the lower qualities are green in colour, and have a nauseous odour and acrid taste.



2. ANGLO-AMERICAN OIL PRESS
(Rose, Downs & Thompson, Ltd.)

Olive oil is composed mainly of olein, with smaller proportions of linolin and palmitin. It may be looked upon as an example of a *non-drying* oil. The proportion of free fatty acids present in the commercial oils depends upon the care with which they have been prepared, and ranges from less than 1 per cent. to about 25 per cent., the specific gravity of the oil diminishing as the fatty acids increase.

The finest qualities are reserved for edible purposes; other varieties are used for burning, for the lubrication of machinery, in the manufacture of woollen goods, in dyeing, and for soap-making.

Olive oil, on account of its relatively high price, is very frequently adulterated, cottonseed, arachis, rape seed, and other oils being used.

Olive-Kernel Oil, as its name implies, is obtained from the seeds in the olive stones; it closely resembles olive oil, but is higher in specific gravity.

Almond Oil. Almond oil is expressed from either bitter or sweet almonds, and is quite distinct from the essential oil of bitter almonds. It has little odour, a mild taste, and is pale yellow in colour. It withstands a very low temperature without becoming solid, and is employed largely in pharmacy.

Arachis Oil. Arachis (earthnut, groundnut, peanut) oil is obtained from the nuts of *Arachis hypogæa*, a plant indigenous to America, but cultivated in Africa, India, and other countries. The oil is pale yellow in colour, and possesses a nut-like odour and taste. The finer qualities are used as salad oil and for the adulteration of olive oil, and the inferior qualities for soap-making.

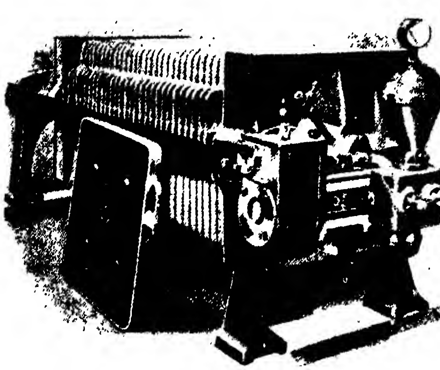
Cottonseed Oil. Cottonseed oil has recently become a product of much commercial importance, and is expressed in large quantities in America, Europe, and Great Britain from the seeds of various cotton trees of the *Gossypium* species cultivated in the United States, in Egypt, East India, etc. The seeds yield from 20 to 25 per cent. of oil.

The crude oil is dark brown, or nearly black, in colour, and is refined by treatment with alkali. The refined product is pale or golden yellow in colour and has little taste or smell.

Cottonseed oil may be considered as a type of a *semi-drying* oil. When air is blown through the heated oil oxygen is absorbed, and the specific gravity and the viscosity of the oil are raised; the resulting *blown oil* is employed in admixture with mineral oils for lubricating machinery.

Refined cottonseed oil is used to some extent for edible purposes, and for the adulteration of olive, lard, and other oils; very large quantities are employed in soap-making and in the manufacture of margarine.

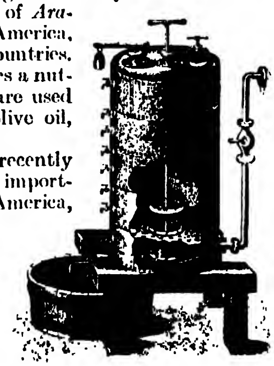
Maize Oil. Maize (corn) oil is obtained from the seeds of *Zea mays*, and is imported from the United States of America in large quantities. It is golden yellow in colour and has a peculiar taste. It is employed principally in the making of soft soap, and to a smaller extent for edible purposes, and for burning.



4. HYDRAULIC FILTER PRESS WITH STEAM PUMP
(Rose, Downs & Thompson, Ltd.)

Rape Oil. Rape or colza oil is obtained from the seeds of *Brassica campestris*, and from many varieties of this plant grown in France, Germany, Russia, and India. The seed contains from 33 to 43 per cent. of oil, and the quality of the latter varies with the origin of the seed. The crude oil, obtained by the pressing or extraction of the seed, is dark brown in colour, and is refined by treatment with sulphuric acid. The refined product, as it occurs in commerce, is light yellow in colour, and has an unpleasant taste and characteristic odour.

Rape oil behaves like cottonseed oil when subjected to air blowing, and stands between drying and non-drying oils. Chemically, it consists mainly of stearine, olein, and erucin, and is peculiar in possessing a somewhat low saponification value.



3. DIGESTER FOR RENDERING FATS

Large quantities of rape oil are used for lubricating purposes, and smaller proportions for burning and in the making of soft soap.

Linseed Oil. Linseed oil is obtained by pressing the seeds of the flax plant (*Linum usitatissimum*), which is grown principally in India, Russia, the United States, and Brazil. The seeds are liable to admixture with the seeds of other plants, and this sometimes seriously affects the quality of the oil; the proportion of oil present ranges from 32 to 40 per cent.

The crude oil is generally refined by means of sulphuric acid. The purified oil is yellow or light brown in colour, and possesses an acrid taste and somewhat strong odour. The chemical composition of linseed oil is not definitely known, but the glycerides of linolic acid, $C_{18}H_{32}O_2$, and linolenic acid, $C_{18}H_{30}O_2$, predominate.

Linseed oil is the most important of the drying oils; it combines readily with oxygen, drying on exposure to the air, and it is to this property that its extensive use in the manufacture of paints and varnishes, and of linoleum is due, the "boiled" or partly oxidised, oil being generally employed. In combining with oxygen heat is evolved, which sometimes causes the spontaneous ignition of cotton-waste and other inflammable materials saturated with the oil. Linseed oil is also largely employed in the making of soft soap.

Castor Oil. Castor oil is obtained from the seeds of the castor oil plant, *Ricinus communis*, these containing from 46 to 53 per cent. of oil; the plant is a native of India, but is cultivated also in the United States, France, Italy, etc. The best variety of the oil is the *cold-drawn*, which is expressed in the cold; this quality is pale yellow or nearly colourless, and has little objectionable taste or odour; the lower qualities, however, have a nauseous odour and disagreeable taste.

Castor oil possesses a higher specific gravity and viscosity than any of the natural fatty oils, and is distinguished also by its solubility in alcohol, and insolubility in certain proportions of petroleum spirit. Chemically it is composed mainly of the glyceride of ricinoleic acid. The cold-drawn oil is used in medicine, and the inferior qualities in the making of Turkey-red oil and in other manufactures, for lubrication, and in India for burning.

Palm Oil. This fat is obtained from the fleshy coating of the fruit of several species of palm, chiefly *Elais guineensis* and *Elais melanococca*,

which grow extensively along the West Coast of Africa.

The methods employed by the natives for the recovery of the oil are very crude; they generally consist in storing the fruit in holes in the ground until decomposition takes place, when the pulp becomes softened, and the oil rises to the surface or in bruising the fruit with wooden pestles, and boiling with water.

Palm oil varies in colour from bright orange-yellow to dirty red, and in consistency from that of butter to that of hard tallow. The proportion of fatty acids also varies with the particular quality of oil, Lagos and Bonny, for instance, containing from 13 to 20 per cent., and Congo and Salt-Pond from 80 to 90 per cent. The commercial oils often contain very large percentages of water and solid impurities due to the methods of extraction. The odour of the better qualities, such as Lagos and Bonny, is pleasant, but that of the inferior varieties is disagreeable.

The principal constituents of palm oil are the glycerides of palmitin and olein, with free palmitic acid. Palm oil is extensively employed in the manufacture of candles and of soap; the bleached oil is generally used for the latter purpose.

Palm-Kernel (Palmnut) Oil, as its name implies, is obtained from the kernels of the fruit of those palm trees which yield palm oil. It is quite different in its physical and chemical properties from palm oil, and more closely resembles coconut oil.

It is largely used in soap-making.

Coconut Oil. Coconut oil, as it appears in this country, is a white fat of the consistency of lard. It is extracted from the kernels of the coconut (*Cocos nucifera* and *Cocos butyracea*), and possesses the characteristic taste and odour of coconut. Three varieties of the oil occur in commerce: Cochin oil, the finest in colour and quality; Ceylon oil, imported from Ceylon; and copra oil, the fat obtained from the sun-dried, imported kernels. Coconut oil is very complex in composition: it contains the glycerides mainly of myristic acid ($C_{14}H_{28}O_2$), lauric acid ($C_{12}H_{24}O_2$), and smaller quantities of the glycerides of palmitic, stearic, and oleic acids, and of the volatile acids capric, caprylic, and caproic.

Coconut oil is extensively used in soap-making, while the purified and deodorised oil, under certain fancy names, is sold for edible purposes.

Coconut oil, when pressed, yields coconut stearine, which is employed in chocolate-making as a substitute for the more expensive cacao butter; the latter fat is obtained from the seeds or beans of the cacao-tree (*Theobroma cacao*).

Chinese Vegetable Tallow. This fat forms the coating of the seeds of the Chinese tallow tree (*Stillingia sebifera*), cultivated largely in China and in some parts of India. It consists mainly of palmitin, with a smaller proportion of olein. It is used in candle-making.

Minor Seed Oils. *Mowrah Seed Oil,* or *Mowrah Butter* (*Bassia longifolia*); *Mahua Butter,* or *Illipe Butter* (*Bassia latifolia*); and *Shea Butter,* or *Galam Butter* (*Bassia Parkii*), are obtained from the seeds of the respective varieties of the *Bassia* tree. The glycerides present are mainly those of stearic and oleic acids; a notable quantity of non-saponifiable matter is also present in some of them, besides varying proportions of fatty acids. These fats are employed in candle-making, and occasionally in soap-making.

Tallow. This is one of the most important of the animal fats, and is obtained from the membrane of the tissue of certain ruminants by melting or by rendering.

The tallow of commerce is distinguished as *beef* and as *mutton* tallow; the former is the product from oxen and cows, and the latter from sheep and goats; *mixed* tallow is a mixture of the two products.

Tallow is imported in large quantities from Australia and from North and South America, while the market is supplied also with the *home* tallow of the local melter. The better qualities of tallow are white, and have little taste or odour; but the inferior qualities are more or less yellow in colour, and have a disagreeable and sometimes rancid odour.

Tallow is composed mainly, although not exclusively, of the glycerides stearine, palmitin, and olein. The value of a tallow depends upon the colour, odour, proportion of free fatty acids, and the *titre*, or solidifying-point of the fatty acids. The highly-priced Australian tallows contain less than 0·5 per cent. of fatty acids; the *titre* of mutton tallow may be as high as 49° C., while that of beef is considerably lower. Many low-class tallows contain from 20 to 40 per cent. of free fatty acids.

Tallow is principally employed for soap-making, in the manufacture of margarine, of stearine for candles, and for lubrication.

When tallow is subjected to mechanical pressure a separation of the solid and the liquid portions takes place; the former is known as *tallow stearine*, and is used for candle and soap making, and the latter as *tallow oil*, chiefly employed for lubrication in admixture with mineral oils.

Lard. Lard is the fat of the hog, and varies in quality according to the particular part of the animal from which it has been rendered; the best quality is known as *bladder lard*, and is obtained from the fat surrounding the kidneys. Lard is white in colour, and has a pleasant taste and odour. It resembles tallow in its chemical constitution, but contains, besides the glycerides present in tallow, those of lauric, myristic, and linolic acids. Lard is very liable to adulteration by admixture with cheaper fats. It is used as a butter substitute in cooking, and in the making of margarine. When pressed, lard oil is obtained, which is also employed for edible purposes and as a lubricating oil.

Other Animal Fats. *Bone fat* is obtained from bones by (*a*) boiling with water, and (*b*) extracting with petroleum spirit. The product of the former process is generally superior to that of the latter. The better-coloured qualities are employed in soap-making, and the darker in candle-making.

Under the general terms *melted fat, grease,* etc., are included a number of somewhat soft animal fats of varying quality, more or less dark in colour, and strong in odour, employed as substitutes for tallow in soap and in candle-making.

Butter fat is the fat present in cows' milk, normal butter of good quality containing about 90 per cent. of fat. Butter fat is very complex in constitution, but consists largely of the glycerides of palmitic and oleic acids, and those of such soluble fatty acids as butyric, caproic, caprylic, etc., the presence of the butyric radicle being highly characteristic.

Margarine. In England, and in some other countries, the name *margarine* is applied to artificially coloured mixtures of certain animal fats and vegetable oils employed as substitutes for butter: formerly they were designated as *butterine,* and as *Dutch butter.* In America they are sold under the name *oleo-margarine.*

The earliest manufacturing process dates from the year 1870, and was the result of the experiments of M. Mège-Mouriès. Since then the industry of artificial butter-making has assumed enormous proportions. When the manufacture is carefully and scientifically carried out, and with due regard to the selection of the purest and freshest materials, as well as to the observance of the greatest cleanliness in the various operations, a product is obtained which forms a good substitute for butter, and a valuable article of food.

The fat of the ox and cow (beef suet) is preferred and is exclusively employed in England as the raw material of animal origin; on the Continent the fat of the sheep is sometimes used for this purpose, and in America that of the hog is largely employed. The components of vegetable origin are refined cottonseed, arachis, and sesamé oils; coconut oil and cottonseed stearine are also sometimes used.

For the manufacture, the selected parts of the fatty tissue are removed as quickly as possible from the slaughtered animal, and, after having been cooled, are exposed to a temperature not exceeding 50° C., which effects the separation of the more readily fusible portions of the fat. The melted fat is then allowed to cool gradually in shallow tins, and the crystallised, or "grained" material pressed in canvas cloths. When beef suet is used, the pressed cake is known as *stearine* or *oleo-stearine*, and the oil as *oleo-margarine* or *oleo-oil*, the latter forming the principal component of the margarine of commerce. The oleo-oil is afterwards mixed with the desired proportion of vegetable oil, and with fresh, or sometimes sour, milk, and the mass churned at a uniform and carefully regulated temperature, which not only effects the intimate mixture of the materials, but also prevents the graining of the harder fat present. The product is then quickly cooled in tanks by means of ice-cold water, removed to an inclined table to allow the bulk of the water to drain away, and taken to kneading machines, which remove a further quantity of water, and produce a homogeneous mass. The desired quantity of salt is then added, with a little annatto or other colouring matter, the margarine again kneaded, and put up into rolls or pats for the market.

The proportions of the ingredients used in the making of margarine vary considerably. The following has been given as a general working recipe (Lewkowitsch): Mix 65 parts of oleo-margarine, 20 parts of vegetable oils, and 30 parts of milk; 100 parts of finished product are obtained, 15 parts of water being eliminated. Margarine is largely employed for the adulteration of butter, although its presence can be detected with some certainty by the improved methods of chemical analysis. In England no butter substitute is allowed to be sold without a declaration of its real nature.

Marine Oils. *Sperm oil* (*Southern sperm*) is the oil obtained from the head cavities and blubber of the cachelot or sperm whale (*Physeter macrocephalus*). The oil, after separation of the spermaceti, and purification, is pale yellow in colour, with little odour, and is distinguished by its low specific gravity and viscosity.

Sperm oil contains no glycerides, but consists of the esters of monohydric alcohols, and should, chemically, be looked upon as a liquid wax. It is much valued, and is extensively used as a lubricant for spindles and light machinery. On account of its high price, sperm oil is often adulterated.

Arctic sperm oil (*Bottlenose*) is obtained from the bottle-nose whale (*Hyperodon rostratus*). This oil very closely resembles Southern sperm oil in its physical and chemical characteristics, but differs in taste, and is more liable to "gum" on exposure to the air. On account of the latter property, its commercial value is generally considerably less than that of Southern sperm, and it is often employed for the adulteration of the more expensive oil.

Whale oil is extracted from the blubber of the Greenland, or "right" whale (*Balæna mysticetus*), and from that of various species of *Balæna* and *Balænoptera*.

Whale oil is a glyceride of uncertain composition,

PHYSICAL AND CHEMICAL CONSTANTS OF THE PRINCIPAL OILS AND FATS

Oil or Fat.	Specific Gravity, 15° C.	Melting Point, ° C.	Solidifying Point, ° C.	Sapon. Value (mgs. KHO pr. 1 gm. oil).	Iodine Value, Per cent.	Titre, ° C.
VEGETABLE OILS AND FATS						
Olive oil	0·915 to 0·918	—	− 5 to + 2	185 to 196	79 to 88	17 to 26
Olive-kernel oil	0·918 to 0·920	—	—	182 to 184	87 to 88	—
Arachis oil	0·917 to 0·921	—	− 3 to 0	190 to 196	83 to 103	28 to 29
Cottonseed oil	0·922 to 0·925	—	0 to +10	192 to 196	105 to 110	33 to 35
Maize oil	0·921 to 0·925	—	−10 to −20	188 to 193	112 to 125	18 to 20
Rape (colza) oil	0·913 to 0·917	—	− 2 to −10	170 to 178	94 to 105	12 to 14
Linseed oil	0·931 to 0·935	—	−20 to −27	188 to 195	170 to 195	19 to 21
Castor oil	0·960 to 0·968	—	−10 to −18	178 to 186	83 to 86	—
Palm oil	0·921 to 0·925	27 to 43	18 to 46	196 to 202	50 to 53	43 to 47
Palm-kernel oil	0·952	23 to 28	20 to 26	242 to 250	13 to 15	20 to 25
Coconut oil	0·925	20 to 26	15 to 22	246 to 264	8 to 9·5	22 to 25
Chinese vegetable tallow	0·918	36 to 46	25 to 33	196 to 201	28 to 38	51 to 54
ANIMAL OILS AND FATS						
Tallow (mutton)	0·937 to 0·953	43 to 48	35 to 43	192 to 197	34 to 48	43 to 49
Tallow (beef)	0·943 to 0·953	41 to 46	27 to 35	192 to 199	36 to 47	43 to 45
Lard	0·933 to 0·938	36 to 46	27 to 30	194 to 197	50 to 70	39 to 42
Lard oil	0·916 to 0·918	—	− 4 to + 5	191 to 196	67 to 82	—
Bone fat	0·914 to 0·916	21 to 22	15 to 17	190 to 196	46 to 56	40 to 42
Butter fat	0·926 to 0·940	28 to 31	20 to 26	221 to 232	25 to 38	35 to 38
MARINE OILS						
Sperm oil (Southern)	0·879 to 0·884	—	4 to 7	123 to 132	81 to 86	11 to 12
Arctic sperm oil	0·878 to 0·882	—	3 to 5	123 to 135	76 to 84	8 to 9
Whale oil	0·920 to 0·925	—	− 6 to + 2	188 to 194	120 to 130	23 to 24
Cod-liver oil	0·924 to 0·931	—	−10 to 0	177 to 195	154 to 170	17 to 18

and differs in this respect and in its higher specific gravity from the sperm oils. It is also more liable to gum, and, in consequence, is not so suitable as a lubricant. The refined oil is used in soap-making, and the inferior qualities for the dressing of leather.

Cod-liver oil, as indicated by its name, is obtained from the liver of the cod (*Gadus morrhua*). Several qualities occur in commerce. The pale and light brown are used in medicine, and the dark brown in the leather industry. Cod-liver oil consists of a complex mixture of various glycerides.

Physical and Chemical Tests for Oils and Fats. For a description of the methods employed reference should be made to analytical works on the subject, but the following outline will serve to indicate the principal points of the examination generally adopted:

Colour, odour, taste, consistency.

Specific gravity at some definite temperature, 15° C. being commonly taken.

Melting and solidifying points.

Viscosity, or liquid friction of an oil, indicated by the rate of flow through an aperture of definite size, at a recognised temperature and pressure, the result being generally given in comparison with rape oil.

Saponification value (or Köttstorfer value), indicating the amount of alkali required for the saponification of a definite quantity of oil or fat, and generally expressed in milligrammes of potassium hydrate (KHO) per 1 gramme of substance.

Iodine (or *Bromine*) *value*, giving the percentage of iodine (or of bromine) absorbed by an oil or fat, and indicating the proportion of unsaturated fatty acids present.

Titre, or solidifying point of the fatty acids of an oil or fat, generally determined by Dalican's method.

Among other physical points there may be mentioned: *microscopic appearance, refractive index, absorption spectra*; and, among chemical points, *acid value*; *Reichert value, Hehner value, acetyl value*; *elaidin test*, and *thermal* and *colour tests* with various chemical agents.

Bibliography. The following works may be consulted; some of them give information also on the allied subjects—waxes, candles, soap, and glycerin—to be dealt with later:

"Chemical Technology and Analysis of Oils, Fats, and Waxes" (J. Lewkowitsch, 1904).

"Animal and Vegetable Fixed Oils, Fats, Butters and Waxes" (C. R. A. Wright and C. A. Mitchell, 1903).

"Commercial Organic Analysis," Vol. II., Part 1 (A. H. Allen and H. Leffmann 1899).

"A Practical Treatise on Animal and Vegetable Fats and Oils" (Wm. T. Brannt, 1888).

"Lubrication and Lubricants" (L. Archbutt and R. M. Deeley, 1900).

"Soap and Candles, Lubricants and Glycerin" (Wm. Lant Carpenter and H. Leask, 1895).

"Oils and Varnishes." "Soaps and Candles" (J. Cameron. Churchill's Technological Handbooks).

WAXES

Waxes are substances of animal or vegetable origin, composed, like oils and fats, of carbon, hydrogen, and oxygen, but differing from them in some of their physical properties, and essentially in their chemical constitution.

The true waxes consist of esters of the higher fatty acids and mono- or di-hydric alcohols, and, unlike oils and fats, they do not yield glycerol on treatment with alkalies. The term *wax*, however, has popularly a wider significance, and is applied to certain substances which, while possessing the physical properties of waxes, are different from them in chemical constitution.

Thus, solid paraffin is sometimes called a wax, although it is a hydrocarbon, and contains no oxygen; and Japan wax, while possessing the physical properties of a wax, behaves chemically as a glyceride. As regards chemical constitution, certain oils, like sperm oil, should be classed as waxes, although they are liquid at ordinary temperatures.

Waxes behave like oils and fats with such solvents as water, alcohol, ether, petroleum spirit, etc. When heated, on account of the absence of glycerol, waxes do not evolve the characteristic odour of acrolein, and they do not become rancid on keeping, differing in these respects from oils and fats.

Beeswax. Beeswax is a secretion of the common bee (*apis mellifera*) and is used by this insect in the formation of the cells of the honeycomb. To obtain the wax, the combs, after removal of the honey, are boiled with water, the impurities strained off or allowed to settle, and the clear wax run into moulds. The product is more or less yellow in colour, and possesses a slight taste and characteristic honey-like odour. It is brittle when cold, but softens readily in the hand, and melts at a higher temperature to a clear liquid. Beeswax consists principally of a mixture of myricin (*myricyl palmitate*, $C_{30}H_{61}.O.C_{16}H_{31}O$), and free cerotic acid; the latter dissolves when the wax is treated with *hot* alcohol.

White, or bleached beeswax (*Cera alba*, Brit. Pharm.), is obtained by exposing the yellow wax, in the form of ribbons, to the action of sunlight in the presence of water; chemical treatment is also sometimes employed. It is used in candle-manufacture and for modelling purposes. Both qualities are very frequently adulterated.

Spermaceti. Spermaceti occurs in the oil present in the head cavities and blubber of the sperm whale (*Physeter macrocephalus*). It is separated from the oil by cooling and by repeated pressing, and is further purified by washing with caustic potash solution. The product appears as a beautifully white, semi-transparent, crystalline mass, with little taste or odour. Chemically, it is composed mainly of *cetyl palmitate* ($C_{16}H_{33}.O.C_{16}H_{31}O$). Spermaceti is employed in the making of sperm candles, and as an ingredient of certain ointments.

PHYSICAL AND CHEMICAL CONSTANTS OF THE PRINCIPAL WAXES

Wax.	Specific Gravity, 15° C.	Melting Point, ° C.	Solidifying Point, ° C.	Sapon. Value (mgs. KHO pr. 1 gm. wax).	Iodine Value, Per cent.	Titre, ° C.
Beeswax (yellow) ..	0·962 to 0·970	61·5 to 64	60·5 to 63	90 to 98	8 to 11	—
Spermaceti	0·905 to 0·960	42 to 49	42 to 47	123 to 130	3·8	—
Chinese (insect) wax	0·926 to 0·970	81 to 83	80 to 81	80 to 93	1·4	—
Carnaüba wax ..	0·990 to 0·999	83 to 85	80 to 82	80 to 85	13·5	—
Japan wax	0·970 to 0·980	50 to 55	45 to 52	214 to 222	4 to 7	59 to 60

Chinese Wax. Chinese (insect) wax is secreted by an insect (*Coccus pela*) living on the twigs of a tree growing in Western China. It is almost white in colour, and resembles spermaceti in appearance, but is much harder and more fibrous in structure. It consists mainly of ceryl cerotate. Insect wax is used in China and Japan as a candle material, and for sizing paper and textile goods, but it is not of much commercial importance in Europe.

Carnaüba Wax. Carnaüba wax is obtained from the leaves of a Brazilian palm (*Copernicia cerifera*) It is yellowish green in colour, and extremely hard and brittle. In composition it is somewhat complex, but consists principally of myricyl cerotate and myricyl alcohol. Carnaüba wax is employed in small quantities in candle-making and in some polishing compounds.

Japan Wax. Japan wax, although possessing some of the physical properties of a wax, is really a fat, consisting mainly of palmitin, and yielding glycerol on saponification. It is obtained from the fruit of certain species of *Rhus* growing in Japan and California. Japan wax is pale yellow in colour and rather unpleasant in smell. It is employed as an ingredient in polishes.

Myrtle Wax. Myrtle (laurel) wax resembles Japan wax in chemical composition. It is obtained from the berries of *myrica cerifera* and other shrubs of this species in America, but is of little importance industrially.

Paraffin Wax. Paraffin wax, ozokerit and ceresin, are of mineral origin and are not true waxes [see Petroleum and Candles].

The waxes are identified by the same tests as those mentioned under Fixed Oils and Fats.

CANDLES

Of the illuminants in use at the present time there are few that possess so many and varied advantages as those offered by the candle. In the electric light, in gas, and in petroleum we have illuminants with which the candle cannot compete as regards intensity of light, but these do not possess the same advantages as the candle in its ready portability, in the softness of its light, and in its general convenience and adaptability.

To the ordinary observer the candle appears to be of very simple construction—merely a cylinder of wax or fatty matter with a central wick—but there are indeed few illuminants upon the production and perfecting of which there has been expended the same amount of scientific skill.

The candle can lay claim to an origin of great antiquity. It is first mentioned by Pliny (in the first century), who states that the candles in use in Greece and Rome were composed of flax threads coated with pitch and wax; but even at a much earlier date, the torch, which possesses the essential features of the candle, is known to have been in use. It is a matter of common knowledge that in King Arthur's reign the time of day was observed by the burning of wax candles of definite length, and they were then employed also in religious festivals. In 1484 a wax chandlers' company was incorporated in England, showing that the manufacture had then attained to some importance. The subsequent development of the industry is naturally divided by two memorable events into two distinct stages, which may be distinguished as the Stearine and the Paraffin period respectively. The first was due to the researches of Chevreul on fatty bodies, published in 1823, followed at a later date by the practical application of these researches by, among others, M. de Milly, in France, and the late Mr. G. F. Wilson, F.R.S., of Price's Patent Candle Company Limited, in England. The second was due to the production on a commercial basis of paraffin wax by the late Mr. James Young, in 1850, and the obtaining of petroleum by drilling, in America, in 1859, this material yielding paraffin wax. The modern improvements in the methods of forming candles have also contributed very materially to the development of the industry.

Candle Materials. In the earlier days of the industry, tallow, beeswax, and spermaceti were the principal materials used, but these, although still employed, have now a very limited application compared with the two materials, paraffin and stearine, of which the great bulk of the candles of the present day is composed.

Stearine. In a commercial sense the term *stearine* is generally applied to the solid fatty acids, stearic and palmitic, or mixtures of these, obtained from animal and vegetable fats, although the term more correctly designates the solid fat obtained after removing the liquid oil from neutral fats by pressure.

Stearine is known as *saponified* and as *distilled*, the former being generally obtained from tallow by saponification or hydrolysis, and the latter from fats of darker colour by saponification followed by distillation, or by acidification and distillation. The raw materials employed for the making of stearine are principally tallow, palm oil and greases.

The object of saponifying the fat, which is the first stage in the manufacture, is to effect the removal of the glycerin and thus obtain the fatty acids. Several processes are in use for this purpose.

Lime Saponification. This is one of the earliest processes, but it is now little used. The fat, mixed with about its own weight of water, is heated in a wooden, lead-lined vat by means of free steam supplied through a perforated coil. The necessary quantity of lime, from 14 to 15 per cent., which is considerably in excess of that theoretically required for the saponification of the fat, is then added in the form of a cream, and the boiling continued until the saponification has been completed. The lime-soap formed separates from the glycerin-water, or *sweet water*, as it is technically called, and the latter can be drawn off. The lime-soap, after having been washed, is decomposed by boiling with dilute sulphuric acid, when the sulphate of lime is precipitated, and the liberated fatty acids rise to the surface. This process, although offering the advantage of simplicity as regards the plant required, is somewhat costly on account of the large percentage of lime required for the saponification, and of sulphuric acid for the decomposition of the lime-soap, while the sulphate of lime is liable to retain, mechanically, part of the fatty acids.

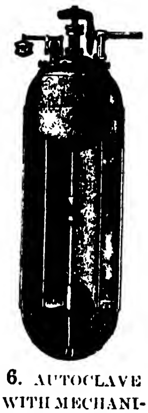
5. AUTOCLAVE

Hydrolysis Under Pressure by Lime. This process was first carried out industrially by M. de Milly, in 1855, and is now extensively employed. It offers the advantage of enabling the saponification to be effected by a reduced percentage of base. The vessel used—the *autoclave*—is made of strong copper, and is generally cylindrical in form, as shown in 5. The fat, mixed with about one-third or one-half of its weight of water and from 1 to 3 per cent. of lime, is introduced

through the funnel-tube, the opening closed, and high-pressure steam passed through a pipe extending to the bottom of the vessel. The usual working pressure is about eight atmospheres, or 120 lb. per square inch, which is maintained for from five to eight hours, when the saponification of the fat becomes practically complete. The contents of the vessel are then blown into a tank, the sweet-water drawn off from below, and the mixture of fatty acids and lime-soap, after washing, boiled with dilute sulphuric acid to eliminate the lime, when the fatty acids are ready for further treatment.

A base, such as magnesia or oxide of zinc, which yields a soluble sulphate, is sometimes substituted for lime. Various forms of autoclave are employed. Fig. 6 illustrates one constructed so as to permit the mechanical agitation of the contents; horizontal and spherical autoclaves, with mechanical agitators, are also in use.

Hydrolysis Under Pressure by Water. It is possible to effect the hydrolysis of the fat under pressure by water alone, without the assistance of a base. The first attempt in this direction was made by R. A. Tilghmann (English Patent No. 47, 1854), and more than one form of autoclave has been constructed within recent years with this object. In L. Hugues' apparatus (English Patent No. 6,562, 1885) provision is made for the intimate mixing of the contents of the vessel by allowing steam to escape while the process is in operation; the working pressure is 15 atmospheres.



6. AUTOCLAVE WITH MECHANICAL AGITATOR

In the system of A. Michel (English Patent No. 8,403, 1885) there are two cylindrical autoclaves, in which the fat and water are heated by fire only, and an intimate mixture takes place; the pressure is maintained at 15 to 16 atmospheres for about eight hours.

A process for the hydrolysis of the fat at the ordinary atmospheric pressure by means of superheated steam, and for the distillation of the fatty acids and glycerin, was patented by G. F. Wilson and G. Payne (English Patent No. 1,624, 1854), but is now only of historical interest.

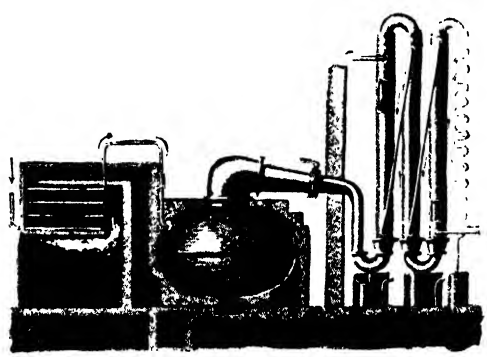
Hydrolysis by Sulphuric Acid. The immediate effect of sulphuric acid upon neutral fats is the formation of sulpho-compounds, which subsequently, on boiling with water, are resolved into fatty acids, glycerin and sulphuric acid. In practice the dried fat is heated to about 120° C., sometimes to a considerably higher temperature, from 3 to 6 per cent. of sulphuric acid of 1·82 to 1·84 specific gravity added, and the acid allowed to remain in contact with the fat for several hours, while the mixture is agitated. The mass is then boiled in a vat with water for some hours, and after settling, the lower layer, containing the sulphuric acid and glycerin, is run off, while the dark-coloured fatty acids are removed for distillation.

This process is now generally applied only to inferior fats capable of yielding little glycerin, and, as a method of purification, to fatty acids from which the glycerin has been already separated. Although it involves serious loss of material, it possesses certain important advantages. These are (*a*) a higher yield of solid fatty acids (although of lower melting-point) than that obtained by any of the processes mentioned, due to the action of the sulphuric acid upon the oleic acid; (*b*) the decolorisation of dark-coloured fatty acids, such as those from palm oil and low-class animal fats; and (*c*) the destruction of foreign substances, which might be liable to affect the keeping properties of the stearine.

Hydrolysis by Twitchell's Process. The reagent employed is prepared by treating a mixture of oleic acid and any member of the aromatic series, such as benzol, phenol, naphthalene, etc., with an excess of sulphuric acid (English Patent No. 4,741, 1898). The cleansed fat, mixed with about half its weight of water, and from 0·5 to 2 per cent. of the reagent, is boiled in a wooden vat with free steam for about 12 hours; after settling, the glycerin-water is drawn off, and the fatty matter boiled a second time with fresh water as before. The hydrolysis of the fat is then practically complete, and the fatty acids are ready for distillation, or acidification and distillation. The exact nature of the chemical change taking place in this process has not yet been fully explained, but possibly it depends upon the emulsifying action of the reagent upon the mixture of fatty matter and water.

The advantages of the process are that it can be carried out with simple and inexpensive plant, and at the ordinary atmospheric pressure. It is extensively employed in the United States of America, and also in Europe and elsewhere, for the hydrolysis of dark oils and fats for the making of stearine, and is recommended also for obtaining fatty acids of good colour from tallow and other fats for use in soap-making.

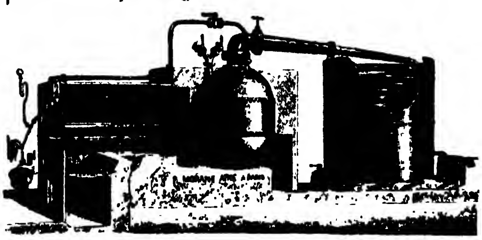
The Distillation of Fatty Acids. The fatty acids resulting from the hydrolysis of the fat by the processes described are often too dark in colour to yield a satisfactory stearine on pressing, and they have therefore to be distilled. Various forms of stills and condensers are in use; the stills are generally made of copper, and are spherical in form, with a capacity of from one to six tons or more. Fig. 7 represents a form of apparatus with vertical condensers suitable for the fractionation of the distillate; in the apparatus shown in 8 the vapours are passed through one condenser.



7. APPARATUS FOR DISTILLATION OF FATTY ACIDS

The fatty acids are heated first by fire underneath the still, and then by superheated steam, which enters the still through a perforated coil near to the bottom of the vessel. As the temperature rises, the steam and the vapour of the fatty acids pass over together, and are condensed, the products being collected in wooden vats, and the condensed water drawn off. The temperature of the distillation is about 260° C., or over. The good

coloured distillate, which has been kept apart from the dark portion coming over towards the end of the distillation, is then transferred to shallow trays arranged in racks, and allowed to cool gradually, in order to obtain the crystallisation of the fatty acids. When cold, the cakes are ready for the final operation of pressing.



8. APPARATUS FOR DISTILLATION OF FATTY ACIDS

The dark residuum in the still is heated by fire and superheated steam to a higher temperature in an iron vessel, when fatty acids of inferior quality distil over, and a residue, known as "stearine pitch," is left. This pitch is jet black in colour, and varies somewhat in consistency, but it is generally hard and brittle. It is employed for the insulation of cables, as a varnish, as a lubricant for heavy rollers, and for other puposes.

Pressing Fatty Acids. The object of pressing is to separate the liquid oleic acid from the solid fatty acids, and is effected generally by two pressings, one being cold or temperate, and the other hot. The crystallised cakes of fatty acids, obtained after the saponification of the fat, or after the distillation of the fatty acids, are transferred to woollen bags, and placed in a hydraulic press of the type shown in **9**. The pressure is applied and maintained until the oleic acid has been removed as far as possible. The cakes, still contained in the bags, are then inserted between the plates of the hot press [**10**], and pressure again applied. These plates are covered with matting made of horsehair, and are heated by steam. A further quantity of oleic acid is removed as well as a portion of the solid fatty acids, the expressed material being afterwards mixed with the next instalment of fatty acids coming forward for pressing. The cakes of hot-pressed stearine, now quite white in colour, are then taken from the bags, the oily edges broken off, and these put aside to be re-pressed. The cold-pressed oil is generally subjected to artificial cooling, and the mass filter-pressed, to separate the solid acids and obtain the oleic acid of low congealing-point.

Oleic acid, or "red oil," is known as *saponification oleine*, or as *distillation oleine*, according to the pro-

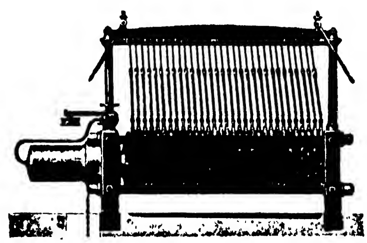
9. HYDRAULIC PRESS FOR COLD PRESSING FATTY ACIDS

cess employed for its production. It is dark brown in colour, and is extensively used as a substitute for the more costly olive oil for the oiling of wool and for the making of oil soaps.

Properties of Stearine. Commercial stearine is a white, more or less crystalline, hard solid; it has only a faint characteristic odour, and should not feel greasy to the touch. The solidifying point of saponified stearine ranges from about 53·5° to 55·5° C., and that of distilled stearine from about 48° to 54° C. It is readily soluble in alcohol, ether, and petroleum spirit. For the purpose of the candle-maker, it is preferred to be close-grained in crystal, and be capable of giving a candle of good "snap" when broken.

Paraffin. Paraffin was first obtained by Reichenbach, in 1830, from wood-tar, and shortly afterwards, and independently, by Dr. Christison, of Edinburgh, from Rangoon petroleum. At that time it was merely a chemical curiosity, its discoverers little dreaming of the great future that lay before it. Its manufacture was first carried out industrially, as already observed, by Mr. James Young, in 1850, from crude petroleum obtained from a spring in Derbyshire, to which Mr. Young's attention had been called by the late Lord (then Dr.) Playfair. This supply becoming exhausted, further experiments were made, which proved that a similar crude oil could be obtained by the low-temperature destructive distillation of certain kinds of coal, the Torbane-hill mineral, or Boghead coal, found in West Lothian, proving one of the most suitable. When this supply also failed, bituminous shale was employed, and this still continues to be used as the source of crude paraffin oil in Scotland. The crude oil contains about 14 to 15 per cent. of solid paraffin, which is obtained by filtration and pressure, in the form of "scale," from the heavy oil separated during fractional distillation—burning oil, lubricating oil, and naphtha being the other products.

The brown coal, or lignite, found in Prussian



10. HYDRAULIC PRESS FOR HOT PRESSING FATTY ACIDS

Saxony, also yields a considerable quantity of paraffin. Paraffin is obtained also from the mineral ozokerit, or earth-wax, found in Galicia and elsewhere. The largest source of supply, however, is American petroleum, which, on distillation, leaves a residuum, and this, on further treatment, yields lubricating oil and paraffin scale. Rangoon, Assam, Roumanian and Galician petroleums also contribute to the production of paraffin.

Refining Crude Paraffin. The crude paraffin wax, or scale, after separation from the heavy mineral oils, is generally yellow or brown in colour. In order to make it available for the purpose of the candle-maker, it must be refined, the object being the removal, not only of the dark oil associated with the paraffin, but also of the lower melting-point paraffins unsuitable for candles. Two methods are employed for this purpose.

Treatment with Naphtha. The melted paraffin scale is mixed with about 30 per cent. of naphtha, or petroleum spirit, the mixture allowed to cool, and the crystallised mass pressed in hydraulic presses. The naphtha removes the oil and the softer paraffins, while the harder paraffins are left nearly white in colour. The treatment may be repeated several times if a highly

refined product be required. The cakes are then melted up, and a current of steam passed through the material, to remove the remainder of the naphtha. The melted paraffin is then decolorised by agitation with a small percentage of animal charcoal, the latter allowed to settle, and the paraffin finally filtered through cloth or filter-paper, and allowed to solidify in shallow pans to be ready for use. The paraffin dissolved in the naphtha is recovered by distilling off the spirit, and, after purification by chemical treatment, it is pressed to remove the oil, when a product of low melting-point is obtained, known as "match wax." This process yields a product of superior quality, but is costly, and on account of the highly inflammable nature of the naphtha, is also dangerous.

Treatment by Sweating. This process, which has largely displaced the one just described, is much simpler, safer, and more economical, and is extensively employed. It was first discovered by Mr. J. Hodges, of Price's Patent Candle Company Limited (English Patent No. 3,241, 1871), and in its original form consisted in allowing the melted scale to cool gradually in shallow tins, in order to obtain good crystallisation, and in subsequently exposing the cakes in heated ovens to remove the oil. It is customary now to allow the crystallisation to take place in large iron trays, supported in racks, within a brickwork chamber fitted with steam-pipes. The temperature of the chamber is then raised, which causes the softer paraffins to melt away, carrying the oil with them. When the sweating has reached the desired stage, the remaining cakes are melted and treated with charcoal, as already described. The "sweatings," after being pressed to remove the oil, are also subjected to the sweating process, and yield a paraffin of lower melting-point than that obtained from the original scale, but also suitable as a candle material.

Properties of Paraffin. Paraffin, when carefully refined, is a beautifully white, transparent substance; the quality known as "semi-refined" is more or less yellow in colour. It is obtained of varying degrees of hardness, according to the melting-point, which ranges, in the case of candle material, from about 46° to 57° C.

Paraffin gives a greater intensity of light than stearine; but, on the other hand, on account of becoming plastic when exposed to heat, it has a tendency, absent from stearine, to bend in a warm atmosphere, this tendency being more pronounced in the case of paraffins of comparatively low melting-point. Paraffin is insoluble in alcohol, but soluble in ether, petroleum spirit, etc.

Blending of Candle Materials. One of the most important operations of candle-making consists in the judicious blending of the two materials, paraffin and stearine, and of other materials, so that full advantage may be taken of those properties of each of the individual substances which will contribute to the best results in the finished candle. A candle composed entirely of paraffin, although attractive in appearance, and capable of affording a brilliant light, is unsuitable for ordinary use, on account of its liability to bend; the addition, however, of the requisite percentage of stearine imparts to it increased rigidity, without destroying its transparency. Thus, ordinary *paraffin* candles contain from 3 to about 10 per cent. of stearine; while others, sometimes called *stearo-paraffin* candles, which are intended to be used in heated rooms or in warm climates, may contain 20, 30, or 40 per cent. of stearine. The addition of the larger percentages of stearine, although reducing the illuminating value of the candle, and rendering it more opaque, greatly increases its stability.

It is important to note that the melting-point of mixtures of paraffin and stearine is lower than that calculated from the melting-points of the two components, so that the melting-point alone, apart from the composition of a candle, does not always give a correct idea of the value of the latter.

On the Continent of Europe stearine candles are largely employed, and these are to be recommended for use in warm climates. For use in churches, candles composed of beeswax, or of mixtures of beeswax and ceresin or paraffin are employed.

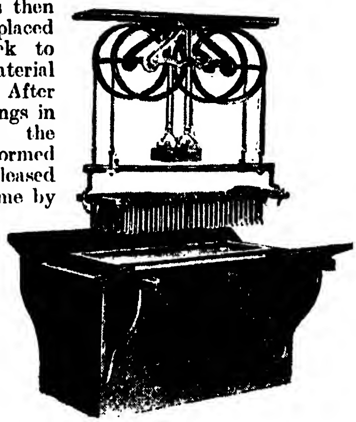
The Wick. Although the wick bears a very small relation to the candle in actual weight, it nevertheless forms an indispensable part of it. What the mainspring is to the watch, what steam is to the engine, so, in point of importance, is the wick to the candle. Its function is to convey a regular and constant supply of liquid combustible material to the flame, so that the candle may burn freely and produce the maximum quantity of light. Formerly, the wick employed for all kinds of candles consisted of twisted strands of cotton, this form being still used for tallow dips; it proved highly objectionable, however, on account of the erect position which it maintained in the flame, becoming soon coated with a mass of unconsumed carbon, which caused the light to become dull and necessitated frequent "snuffing." Many attempts were made to overcome this difficulty, by causing the wick to curl slightly, so that free burning might take place. In 1825, a Frenchman, Cambacérès by name, discovered that by plaiting the strands of cotton it was possible to obtain a wick having the desired property. Although this improvement was introduced into this country shortly afterwards, it was not till 1840 that its value became generally realised, when the late Mr. J. P. Wilson, of Price's Patent Candle Company Limited, employed it in the manufacture of "snuffless composite" candles, which were first used in the illuminations in connection with the marriage of the late Queen Victoria. The plaited wick is now in almost universal use for all kinds of candles. It is composed of fine threads of cotton, specially selected, the plaiting of these being carried out by machinery of delicate construction.

Preparation of the Wick. Before the wick is fit for use, it must be "prepared" by soaking it in a solution of certain chemicals, such as borax, sulphate of ammonia, etc., and afterwards thoroughly dried. The object of this treatment is to give stability to the wick, and at the same time, by forming a fusible ash with the mineral matter of the cotton, to allow the wick to have free action.

Great care requires to be exercised in adjusting the size of the wick to that of the candle, and to the quality of the candle material. If the wick be too large, too much material will be carried to the flame in a given time, and there will be imperfect combustion, resulting in a smoky flame; on the other hand, if it be too small, it will fail to consume all the melted material, which will run down the sides of the candle, and cause "guttering."

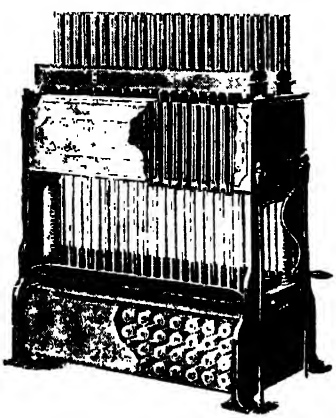
Formation of Candles. Three methods are still in use for making candles. The method of *dipping*, on account of its simplicity, has been used from a very early time. Tallow was employed as the combustible material, and still is, but only to a limited extent, distilled fatty acids of comparatively low melting-point being now generally employed.

One of the most important forms of the dipping machine is shown in **11.** It consists of a trough for containing the melted fatty acids; above it, an iron frame is suspended by chains passing over pulleys, the whole being counterbalanced by weights. The wick is first wound upon an iron frame, which is then immersed in the fatty material, in order to cause the wick to become thoroughly saturated. The frame is then raised, and placed upon a rack to allow the material to solidify. After several dippings in this way, the partially-formed candles are released from the frame by cutting, transferred to wooden rods, and the alternate processes of dipping and cooling continued until the dips have acquired a sufficient thickness, which is indicated by the weights on the machine.



11. DIPPING MACHINE (Price's Patent Candle Co. Ltd.)

The method of *pouring and rolling* is confined to the making of candles composed entirely, or mainly, of beeswax. The wicks, attached to a wooden hoop, are suspended over a bath of the melted wax; the operator pours the wax over the wicks, and at the same time, while rotating the hoop, he brings each wick into position. In order to obtain uniformity in shape, the partially-formed candles are inverted, and the pouring continued. When they have become sufficiently thick, they are placed upon a marble slab, and rolled to and fro, under a wooden board, which produces the desired smoothness and regularity of surface. The candles are then cut to the desired length, and the tips formed by the fingers, with the assistance of a small piece of wood. At one time, wax candles were rolled only.

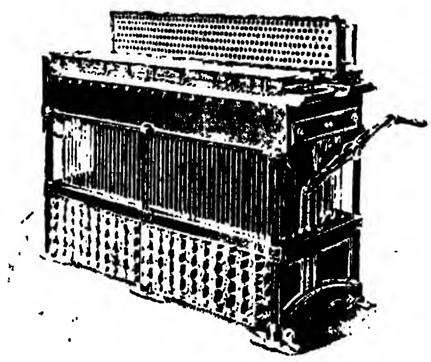


12. CANDLE-MOULDING MACHINE

The method of *moulding* was introduced by Sieur de Brez, in the fifteenth century, but since then it has been brought to its present state of perfection by the skill and ingenuity of many inventors. It is now the principal mode of forming candles.

The modern machine, one form of which is shown in **12,** and another and larger form in **13,** consists of an oblong metal tank containing the moulds, the butt-ends of which are placed upwards, and communicate with a trough; the tips are placed downwards, and are attached to hollow piston rods, these resting upon a plate, which, when raised by means of a rack and pinion, causes the piston rods to force the candles from the moulds. The tank is provided with a pipe for conveying steam to heat the moulds, and with another for cold water, to cause the material to solidify. The wicks are supplied from bobbins contained in a box underneath the frame, and pass through the piston rods and moulds.

The candle material—let us suppose a paraffin mixture—is heated in a steam-jacketed pan, and transferred in metal pails to the moulding machine. The moulds are first heated, the steam turned off, and the material poured into them until it partially fills the trough above; cold water is then passed through the tank, until the candles have solidified. Before they are raised, the candles from a previous moulding, supported meanwhile by a wooden clamp resting upon the machine, are removed, after the wicks have been cut by a sharp knife. The excess of material is then taken from the trough, the rack handle is turned, the candles being forced upwards and supported by the clamp, and so the operations are repeated. The forcing of the candles from the moulds is sometimes done by mechanical power.



13. SEXTUPLE "MULTIPLE" CANDLE-MOULDING MACHINE (Edward Cowles)

Stearine candles require to be moulded from the material in a semi-fluid condition; the moulds are heated, and the tank must be filled with tepid, instead of cold, water, to obviate the difficulty arising from the crystalline nature of the material. In order to improve their appearance, stearine candles are generally polished, and the ends cut by special machinery. Sometimes also they are exposed to the action of light to improve their colour.

The candle manufacturer may be called upon to supply an immense variety of sizes, from the tiny Christmas-tree candle, numbering about 80 to one pound, to the tall altar candle, weighing several pounds, but the sizes most commonly used are 4, 6, 8, and 10 candles to the pound.

Self-fitting and Fancy Candles. An improvement in candle-moulding consists in providing candles with what is called a *self-fitting* (S.F.) end, which permits them to be readily fixed in

any size of candlestick. This was first introduced by J. L. Field, in 1861, and since then many different forms have been employed. The conical fluted "cap" which produces the self-fitting end, forms, as a rule, a separate part of the mould.

Fancy candles, such as fluted, and spiral or cable, are moulded in special machines; so also are perforated candles, which are provided with hollow, longitudinal spaces to receive any excess of melted material, to prevent "guttering." Fig. **14** shows candles of various forms—*a*, plain; *b*, with S.F. end; *c*, and *d*, fluted, with S.F. end; *e*, spiral or cable, with S.F. end; *f*, spiral, with tapered end; *g*, perforated. Candles may be coloured to any desired tint by dissolving the colouring matter, generally an aniline derivative, in the candle material. Many also bear artistically designed representations of flowers, etc., painted by hand, or ornamented by transfers.

The Standard Candle. For measuring and recording the intensity of light of different illuminants, it is necessary that there should be a definite fixed standard. For this purpose, the *standard candle* has long been, and still is, in use; and, although it has been replaced to some extent in this country by the Harcourt Pentane Lamp, which has been accepted as the legal standard of light for the metropolis of London, it is customary to refer to the intensity of a given light in terms of the standard candle.

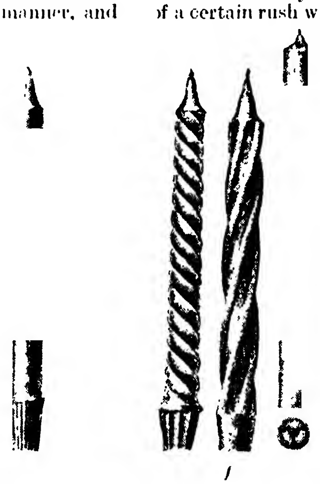
Thus, we speak of gas of 15-candle power—that is, the gas, when burned in a recognised manner, and at a given rate of consumption, possesses an illuminating value equal to that of 15 standard candles. In England, the standard candle is composed of spermaceti, containing 3 or 4 per cent. of white beeswax, the latter being added with the object of destroying the crystal of the spermaceti. The size of the candle is six to one pound, and the wick is adjusted so that it consumes 120 grains of material per hour.

Illuminating Value. In determining the illuminating or photometric value, two standard candles are generally employed, and in order to ascertain the exact consumption of material, and thus allow for any irregularity, the candles are supported during the operation on a delicate balance. The photometer employed is generally some form of the Letheby-Bunsen system, whereby the light from the illuminant under observation is allowed to fall upon one side of a paper disc, and that from the standard upon the other side. The disc, with the exception of a circular spot in the centre, is greased, and is placed within a box which slides upon a rod, graduated so that the relative intensity of the two lights can be shown by reference to the scale, the box being moved to and fro until a point is reached when the whole of the disc becomes equally illuminated.

The following table gives the illuminating value, etc., of candles of the same size, composed of the two principal candle materials, paraffin and stearine in comparison with the standard spermaceti candle.

——	Standard Spermaceti.	Paraffin.	Stearine
Observed relative illuminating value (stand. candles)	1·00	1·30	1·06
Consumption (grains material per hour) ..	120·0	124·2	147·6
Number of hours' burning per 1-lb. candles ..	58·33	56·36	47·43
Relative illuminating value for the same consumption (120 grains per hour)	1·00	1·25	0·86

Night Lights and Illumination Lights. These are really small candles, but their delicate construction demands more refined methods for their manufacture than those required for the larger illuminant. They are used in night nurseries and in sick-rooms for giving a clear, though not too strong light; for heating food at night for infants and invalids; for use under coloured shades for table decoration; and for outdoor illumination. The materials employed are generally paraffin, coconut stearine, pressed tallow, distilled fatty acids, or mixtures of these. Night lights are chiefly of two kinds—those in paper cases for burning in a saucer with a little water, such as the well-known "Childs'," and those for burning in glasses, as Price's "New Patent" (English Patent No 2,317, 1853). The material is moulded in frame somewhat similar in principle to those employed for candles, but the wick is introduced in a separate operation. The wick generally consists of fine cotton threads coated with wax; in the "Pyramid" light it consists of the pith of a certain rush with part of the outer skin remaining to support it, and this light is provided with a plaster bottom.



14. VARIOUS FORMS OF CANDLES

In the making of case night lights, the small piece of wick is first secured to the bottom of the case by a little wax, a piece of perforated tin slipped over to act as a support to it when burning, and the moulded material then fitted into the case, the wick passing through a perforation in the material formed in the moulding process. Night lights vary in size, and are made to burn from 5 to 10 or 12 hours.

Lighting Tapers. These are sometimes known as *drawn candles*, or *lighting wicks*. The wick, consisting of fine strands of cotton, is wound from a large hollow revolving drum to another similar drum. Before it reaches the second drum it is made to pass through a bath of the melted wax, and from there through a small perforation in a metal plate in order to remove the excess of material When the wick has been transferred from the one drum to the other the winding is reversed, and the wick thus receives a second coating of material, passing afterwards through a plate with a larger perforation, the process being continued until the desired thickness has been attained. The coated wick is then removed from the drum, cut, and the ends of the tapers feathered to enable them to light rapidly. (Some of the illustrations in this article are reproduced from Lewkowitsch's "Chemical Technology and Analysis of Oils and Fats" by arrangement with the publishers, Messrs. Macmillan & Co.)

Continued

THE LAST OF THE STUART KINGS

James II. and Religious Toleration. A Notorious Judge. William and Mary. An Important Change in the British Constitution

Continued from page 4762

By JUSTIN McCARTHY

THE reign of James II. is a turning point in the history of England, and has been, and is, the subject of much religious and political controversy. James, the second son of Charles I., was born at St. James's Palace on October 12th, 1633, and was immediately created Duke of York. He accompanied his father in the Civil War, was captured by Fairfax, but escaped to Holland in 1648 disguised as a girl. He then went to France, where he took service in the army under Marshal Turenne, the famous French commander. James showed much courage and military skill in the wars with Spain, and won the favour and friendship of Turenne. He afterwards served in the Spanish army. On the Restoration, he returned to England, and was appointed Lord High Admiral.

James was both soldier and sailor; he twice commanded the British fleet in the wars with the Dutch. In 1660, he privately married Anne Hyde, daughter of the Earl of Clarendon. She was then lady-in-waiting to the Princess of Orange. Before her death, Anne became a Catholic, and James is said to have followed her example not long after, although the exact date of his reception into the Church is not known.

Protestant Feeling in England. James, who had until this been very popular with the English people, now became unpopular, and the passing of the Test Act compelled him to resign office. Indeed, the feeling against Catholics had become so strong that it was thought advisable for him to retire to the Continent. The Bill of Exclusion, rejected by the Lords in 1680, failed to pass in the following year because the Parliament was dissolved. James had returned in the meantime to England, and had been sent as Lord High Commissioner to Scotland, where he was very popular, except with the Covenanters, against whom his measures were severe. In 1684, he came back to England and resumed the office of Lord High Admiral.

On the death of Charles II., in 1685, James was proclaimed king. He had married Mary, daughter of the Duke of Modena, in 1673. He then opened relations with Rome, and attended publicly the services of the Catholic Church. In the same year the Duke of Monmouth, who was a natural son of Charles II., and who had a large following among the Protestants of England, led a rebellion against James, whom he refused to recognise as king. He asserted that Charles II had married his mother, Lucy Walters, and that he was therefore legitimate and heir to the throne. He had been banished to Holland, but returned to England, landing at Lyme Regis on June 11th, 1685. He had at first some success, but was entirely defeated at the Battle of Sedgemoor by the Royal troops under Feversham and Churchill. Monmouth escaped, but was discovered after a few days in a dry ditch in Dorsetshire. He showed great fear, and appealed for mercy to King James. He was, however, executed on Tower Hill, July 15th, in the same year. It is said in extenuation of James's unmerciful treatment of Monmouth that a letter written by the latter to the king was kept back from him.

The Infamies of Judge Jeffreys. After Monmouth's rebellion came the infamous "Bloody Assize." Jeffreys, who was made Lord Chief Justice in 1683, presided at the trial of Titus Oates, where, as in all other instances, he was conspicuous for cruelty. He was raised to the House of Lords as Baron Jeffreys two years later, and almost immediately sent to the neighbourhood of Wells to try the insurgents of Monmouth's rebellion. His cruelty was excessive; three hundred and twenty of the rebels were hanged. It is stated in James's memoirs that these atrocities were committed without the knowledge of the king, who was inclined to clemency. Jeffreys was made Lord Chancellor in September, 1685. On the arrival of William of Orange in England, he tried to escape, but was captured and sent to the Tower, where he died in 1689.

James was willing to grant religious toleration to the Dissenters as well as to the Catholics, and if it had been possible in the state of public feeling in England for a Catholic to be sovereign, it does not seem that he would have been intolerant to his Protestant subjects.

The Seven Bishops. The trial of the Seven Bishops, who declined to read the King's Declaration in favour of liberty of conscience; which ended in their acquittal in 1688, aroused much popular feeling against the king. The Protestants regarded the Declaration as intended to restore the Catholics to an equality with those belonging to the Reformed Church, as was, indeed, the king's intention. His measures would, in more modern days, have been considered both wise and just, but the passing of Catholic Emancipation was not for many generations yet. In questions of religious equality, James was in advance of his times. His policy was regarded as an outrage on the rights of those who belonged to the Church of England. James became more and more disliked by the majority of his subjects, and some of his leading statesmen appealed to William of Orange, his nephew and son-in-law, to intervene. William promptly accepted and acted upon the invitation. He sailed for England at the head of a large army, landed at Torbay on November 4th, 1688, and marched at once to London. He was welcomed by the

majority of the people all along the way, who regarded him as their deliverer from Catholicism, and the unfortunate James was betrayed or abandoned by most of his Ministers and soldiers—Churchill being one of the first to go over to the enemy—and even by his daughter Anne. James made many efforts to regain the confidence of the people, but without success; and finding all efforts useless, he sent his wife and infant son to France, where he attempted to rejoin them soon after. He went through many adventures, was captured at Faversham, and brought to London, and then to Rochester. But eventually his presence in England being found rather an embarrassment to William and his party, he was allowed to escape, and joined his wife and child in France, where he was warmly welcomed by Louis XIV., who settled a pension on him and showed him unceasing kindness.

James and the Irish. James did not yet consider his cause hopeless, and, knowing he had many sympathisers in Ireland, determined to make a venture there. He gathered together an army with the help of Louis, composed mainly of French officers and soldiers, and landed in 1689. It is not easy to understand why he failed so hopelessly in this expedition. His cause was that of all the Catholics, the large majority of Ireland's population. Yet from the beginning the cause of King James seemed hopeless. He seems to have obtained, most unjustly, the reputation for cowardice, which was never one of his characteristics; but he was not fitted to be a leader of men. He seemed uncertain what course to pursue, and thus earned in Ireland the reputation of wanting courage and resolve. On the other side, William of Orange had impressed the Irish from the first with admiration for his courage and resolution even while they detested his cause and himself. The Battle of the Boyne, July 1st, 1690, decided the whole campaign. James was defeated and his army suffered severe loss, while the loss to the army of William was comparatively small. James had to abandon, even to fly from the field. He returned to France, and settled at St. Germains, where he engaged in many intrigues to regain the crown, but without success. James left two daughters by his first wife—Mary, married to William III., and Anne, afterwards Queen Anne. His son by his second wife was born on June 10th, 1688. He also left several illegitimate children, of whom the most famous was James, Duke of Berwick, son of Arabella Churchill, the sister of the Duke of Marlborough. Berwick was appointed commander of the French army in Spain, and in 1707 defeated the English and the Imperialists at the great Battle of Almanza.

"James III." of England. James Edward, the Chevalier de St. George, was acknowledged King of England as James III., on his father's deathbed, by Louis XIV. When he was about twenty he entered the French army, and fought at the Battle of Oudenarde. When the Peace of Utrecht was concluded he was compelled to leave France, and went to Lorraine. At this time he was much urged to become a Protestant so that he might have a better chance of succeeding to the throne of England, but he consistently refused to change his religion. On the death of Queen Anne he was proclaimed king at Plombières. When Bolingbroke was at the head of the Government in England, there seemed to be a chance for the success of the cause of the Chevalier. James went to Scotland at the time of the rising headed by the Earl of Mar, but did not arrive there until after the Battle of Sherifmuir. Though brave, James was wanting in energy and decision. The rising failed, and James and Mar, leaving their followers, fled to France. When, in 1717, the English Government compelled the Regent of France to expel James from French territory, he went to Rome, where he was betrothed to Clementina Sobieski, granddaughter of the King of Poland, whom he married in 1719. In the following year Charles Edward was born. James's life was spent in unsuccessful attempts to assert his claim to the crown of England. He died in 1765.

"Bonnie Prince Charlie." His son, Charles Edward, is the hero of many romances. He made a better fight for the crown than his father had ever done, and in 1745 he raised a rebellion in Scotland, where Edinburgh surrendered to him, and he actually held court at his ancestral palace of Holyrood. He won a great victory over Sir John Cope at Prestonpans on September 21st, 1745, and marched towards London, but, after one or two victories on his way, was completely defeated by the Duke of Cumberland at Culloden. Cumberland treated the defeated Highlanders with such brutality that he was known as "the butcher." Charles escaped to France by the help of Flora Macdonald, who saved his life. He made many efforts to get assistance from some of the Continental States, but with no success. He had quarrelled with his father and with his brother, Cardinal York. On the death of his father he went to Rome and, in 1772, married the Princess Louisa of Stolberg; but the marriage was not a happy one, for she eloped with Alfieri, the poet. Charles sank into habits of utter dissipation and died in Rome on January 31st, 1788. With him may be said to have ended the efforts of the Stuart family to regain the crown.

William and Mary. On February 13th, 1689, William III. and Mary were proclaimed by the Convention Sovereigns of Great Britain and Ireland, after the Declaration of Right had been passed. The Bill of Rights was the result of the deliberations of a committee appointed by the House of Commons in 1689 after the Revolution to consider what measures should be taken to prevent the principles of the constitution being violated by any future sovereign, and, further, for the purpose of enacting several new laws. After much discussion, it was resolved to fill the throne immediately, but to insert in the instrument which conferred the crown on William and Mary a statement of the fundamental principles of the Constitution. It was also decided that all questions of further reforms or the making of new laws should be postponed to a more convenient time. A committee presided over by Lord Somers framed a Declaration of Rights which the Lords accepted after

making some slight alterations. This declaration was read to William and Mary before the crown was tendered them.

The Declaration of Right. The first section of the declaration stated the various acts which it was the purpose of this measure to prevent in the future on the part of any sovereign of England. The second section declared the resolution of Lords and Commons that William and Mary should become King and Queen, to be succeeded by their lawful issue, or, failing such, by the issue of the Princess Anne. The fourth, fifth, sixth, seventh, and eighth confirmed this, and also confirmed the power of Parliament. The ninth declared that no member of the Church of Rome, or one married to such, could be sovereign of England, and, further, that every King or Queen must subscribe and audibly repeat the Test Act on the first day of their first Parliament. In the twelfth section it is declared that "no dispensation by *non obstante* of or to any statute shall be allowed, except such dispensation be allowed in the statute or be specially provided for by one or more Bills to be passed during the present Session of Parliament."

In Ireland the followers of James II. were still holding out, but the struggle d d not last long. The story of James's campaign in Ireland has been already told. In 1691, Ginkell concluded the Irish war by taking Athlone, winning the Battle of Aghrim and besieging Limerick. The famous "Violated Treaty" was made by the English commanders, but was afterwards repudiated by the Government. In Scotland the crown was offered to William on his accession, but Graham of Claverhouse, Viscount Dundee, raised the Highlanders in the Stuart cause. His death at the Battle of Killiecrankie, in 1689, at the moment of victory, left little chance for the adherents of James II. in Scotland.

The Massacre of Glencoe. The Massacre of Glencoe, at which many of the adherents of the Stuart cause were killed by treachery, must ever be a stain on the memory of William, though it is said that he signed the order without reading it. When the rebellions in Ireland and Scotland were suppressed, William was able to carry out that foreign policy which was always his chief object. He was a man of great ability and of many great qualities, but he was never able, in his lifetime, to win the full sympathy of the English people. His foreign birth was against him, and his love for war was believed to have withdrawn him too much from promoting the domestic improvement of England. His cold, unattractive manners also repelled many of those who had to act with him in affairs of State. In 1672 Marlborough was dismissed from office in consequence of the discovery of his intrigues with the French Jacobites. Though a great soldier, William's campaigns were not always successful. Russell's great victory off La Hague prevented the threatened invasion of England, but William was defeated by Luxemburg in August, 1692, at the Battle of Steinkirk.

An Eventful Year. The following year was also made unfortunate for William by the loss of the Smyrna Fleet and the defeat at Landen. The year 1694 was an eventful one. The death of his wife, on December 28th, was a public as well as a private calamity. The Bank of England was established in this year and the Charter of the East India Company renewed. The disastrous failure of the expedition against Brest, which occurred in the same year, was caused by the French Government being informed, through a letter from Marlborough to King James, of the intentions of the English which were meant to be kept a profound secret. Other important events of this part of William's reign are the establishment of the National Debt as a system; the handing over of the control of the Standing Army to Parliament; the liberty of the Press - at least in principle—and the making of Ministerial responsibility a part of the Constitution. Indeed, it may be said that the British Constitution was then established on the basis which it has ever since maintained.

The Assassination Plot, first designed in 1695, and Berwick's Plot, both of which were discovered before they could be successful, did much for the popularity of William, an association being promptly formed for his protection.

The King and His Dutch Guards. In 1697 the war with France was concluded by the Treaty of Ryswick. In the same year the Bill for the reduction of the Standing Army was introduced, and in the following year the Tory Party carried a Bill which compelled William to dismiss the Dutch Guards. He was so annoyed at this that he wished to leave England, but abandoned the idea on the advice of Lord Somers, his Lord Chancellor. William, displeased by the action of the majority in the Commons in 1698, prorogued Parliament on May 4th, and in the following year dismissed his Ministry; and the Act of Succession, necessitated by the death of the heir to the throne, Anne's son, the Duke of Gloucester, was passed by a Tory Government. In the meanwhile the failure of the famous Darien scheme had caused great discontent in Scotland. The Commons made unsuccessful efforts to impeach the late Ministry for their share in the Partition Treaties. William again prorogued Parliament in June, 1701, and went to Holland to consolidate the Grand Alliance between England, Holland, and the Emperor Leopold against the design of Louis XIV. to make his grandson sovereign of Spain. When King James died, on September 6th, Louis declared his son, James Edward, King of England.

William's career was cut short by a mere accident when he had not long passed his prime. He had returned to England in November, 1701, and on February 20th in the following year his horse stumbled, and he died from the injuries he received. Before his death he gave his assent to the Succession Act, and as he had no children the crown passed to Anne, the second daughter of King James II. by his first wife, Anne Hyde.

Continued

FRUIT PRESERVING

Curing and Drying. Dried Fruits. Canning and Bottling. Pulping. Jam-making. Fruit Jellies. Marmalade. Candied Fruit. Equipment of Factory

THE importations of fruits into Great Britain, after deducting re-exportations, aggregate about 7,000,000 tons, a good proportion of this quantity being used in making jam. To this import supply must be added the fruit which is produced from the 77,947 acres devoted to small fruit-growing in Great Britain, and which does not figure in any fiscal statistics. The number of jam factories in Great Britain is estimated at from 190 to 200, and this does not take any account of the quantity of jam, large in the aggregate, that is made in thousands of households, especially when fruit is cheap.

The Demand for Fruit. The public demand for fruit and preserves is enormous and is not adequately met; within the last two years, for example, very large quantities of bananas have been sold without appreciably affecting the sale of other fruits. Competent authorities have declared that fruit and hop-growing are the only branches of agriculture that really pay in Great Britain, and each year sees an increase in the acreage devoted to fruit-growing. The cultivation of apples for cider-making is also a growing industry; but the increase in acreage already alluded to is accounted for almost entirely by land devoted to other varieties of fruit. Jam-making is really the result of cheap sugar, and many of the larger factories have grown up within the last ten or fifteen years. The fruit imported into Great Britain comprises the dried fruits, such as currants, raisins, and prunes, together with fresh fruits, such as oranges, lemons, apples and pears, fruit pulp and candied fruits.

Oranges and Lemons. Oranges and lemons are the most easily marketed fruits. They come from the Mediterranean coast, China, the Azores, Mexico, Australia and California. The oranges are gathered when not quite ripe, those fully formed and with the colour just turning from green to yellow being selected. Careful handling is essential since rough handling results in bruising. The oranges are simply wrapped in fine paper or in the husk of Indian corn and put into boxes, the sides of which have air spaces. Lemons keep better than oranges and are less liable to injury during the voyage; the greater part of the lemons grown are used as a source of citric acid.

Currants and Raisins. Currants, the dried seedless fruit of a dwarf variety of grape vine are produced in the Ionian Islands. The currants when sufficiently ripe are gathered and placed in layers exposed to the sun, being turned from time to time, and swept into heaps. When drying is complete the stalks have become detached. The currants are then separated from the debris and packed into casks for exportation.

Raisins are also a product of the grape vine, and are grown in Spain, Italy, Greece, the South of France, and California. The grapes are left on the vines after they have come to maturity, and the autumn sun is relied upon to do the necessary drying. Another way and one practised in the newest raisin-growing districts is to cut the bunches of grapes from the vine and place them in shallow trays 2 ft. wide, 3 ft. long and 1 in. deep. The raisins are then sun-dried, being turned from time to time by inverting a full tray on an empty one. The average time of drying is three weeks, depending obviously upon the weather. After the raisins have been dried they are stored in "sweat" boxes until ready for packing. To avoid delay in drying and any risk of getting the fruit wet through showers, some large growers have curing-houses, where the drying is finished after the raisins have been partly sun-dried. Sun-dried fruit is far superior to that partly dried by artificial means. The drying-houses in use in Spain consist of a chamber 25 ft. long, 15 ft. wide and 10 ft. high, the heat being supplied from a furnace outside and conveyed throughout the building by a 9 in. flue. There is a vent for air at each corner. The temperature must not exceed 120° F., the most suitable for ensuring good fruit being 100° F. It should be noted that some exposure to sunlight is absolutely necessary in drying raisins.

Why Raisins Look Glossy. In some parts of Spain and France the raisins are dipped, previous to drying, in a weak *lye* from wood ashes to soften the skin and give the raisins a clear, glossy appearance. Drying is much facilitated by the preliminary dip in alkali. The dipping bath used for Valencia raisins is made by mixing the following ingredients: Wood ashes, 10 lb.; sulphur, ½ lb.; olive oil, ½ pint; water, 8 gall. Stir the ingredients together and allow to settle. The solution is then transferred to a cauldron and heated to nearly boiling point before dipping the raisins. Occasionally, the dipping is dispensed with, the liquid being distributed over the fruit by means of a whisk. The method recommended by the Victoria Department of Agriculture for making pudding raisins is to dip the grapes as soon as gathered into a boiling lye made by mixing 1 lb. of Greenbank concentrated lye with 15 gall. of water. The fruit is immersed for from 20 to 30 seconds, the effect of the lye being to break the skin into minute cracks, and so facilitating the escape of moisture in the subsequent drying. The dipped fruit dries in from 8 to 12 days in bright weather. To give the fruit a bright amber colour, much preferred by the housewife, a sulphuring process is employed. The trays of raisins are stacked in a small chamber and exposed to the fumes of burning sulphur for from 40 to 50 minutes. The sulphuring has the effect of bleaching the dark colour and increasing the value of the fruit in the market. Stemming (removing the stalks) and grading are performed by a simple machine, but two home-made wire sieves of ⅜ in. mesh and ¼ in. mesh answer perfectly when very large quantities are not being treated.

Dates. Some varieties of dates require practically no curing, being ready to pack and ship as soon as they have ripened. Other varieties, however, need some preparatory treatment. Dates are borne in bunches which have a single stem with numerous slender twigs to which the fruit is

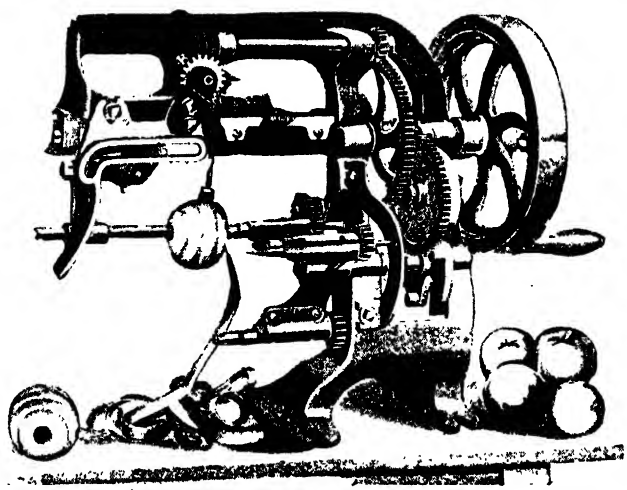
attached. A bunch carries from 10 to 30 pounds of fruit. It is very rare that all the dates on a bunch ripen at the same time, and in the case of choice varieties, those which first ripen are often hand-picked and shipped at once in order to get the high prices paid for the earliest consignments. It is also claimed that picking the outer dates of the bunch, which usually ripen first, permits the inner fruit to ripen better. Frequently when most of the dates on a bunch are ripe and the rest are beginning to ripen the whole bunch is cut off and hung up in a dry and shady place. In a few weeks the whole bunch is ripe and ready for shipment. The choice varieties of dates are shipped from the Sahara, either in bags or long, wooden boxes, and afterwards repacked in smaller boxes. The above methods apply to the Deglet Noor variety, which is chiefly exported from Algiers. The Rhars variety, which is full of sugary juice, is not so easily handled. The Arabs usually hang up the bunches and allow the juice to drain off into jars. This juice is called *date honey*, and when it has drained off the fruit is ready for packing into boxes or skins. When packed tightly dates keep for years without any deterioration in quality.

Prunes. Prunes are simply dried plums. The best kinds are simply sun-dried after careful selection for quality. The plums are allowed to ripen thoroughly before being gathered.

The alternative process used in some districts involves the use of a lye bath, as for raisin-curing, to soften the skins and facilitate drying. The softening in other cases is done by half cooking the dried plums for from two to three minutes in water to which glycerin, in the proportion of 1 lb. to 20 gallons, is added. The plums are then dried for three or four days, and then packed in glass bottles that are tightly sealed. The lighter coloured prunes are submitted to a sulphuring process.

Figs. Figs come chiefly from Asiatic Turkey, though Portugal, Spain and Greece send small quantities. The figs are allowed to drop from the trees; the fruit does not bruise because it is dry. The figs are then exposed to the sun on dry grass for three or four days. Smyrna is the centre of the fig producing district, the growers bringing in their produce in sacks. Damp is injurious in the drying process, and the pre-eminence of Asiatic Turkey is due to the climate being perfect for fig-drying. In Spain the climate demands that the figs must be covered up with boards or canvas during the night or they would spoil.

Desiccated Fruits. Desiccated fruits include dried apples, apricots, and peaches. It is questionable whether the demand for dried apples is so large as formerly, as the preference is naturally given to the fresh apples now obtainable all the year round. The *dried apples*, or *apple rings*, as they are called, have, however, the advantage of cheapness, and when rejuvenated by soaking in water, are a really passable substitute for the fresh fruit. The apples are pared, cored, and sliced by machinery, one of the machines being illustrated in 1. As soon as peeled, the apples are dropped into salt water, and after a few minutes' immersion, are put in the sulphur box, and fumed for from 30 to 35 minutes. The slices are then spread on trays, and placed in the sun for four or five days, being turned once. When artificial drying is employed, a chamber or evaporator supplied with a current of air at 240° F. is used. The trays of apple slices are taken through the evaporator on an endless chain, moving every three or five minutes. A bushel of apples makes 5 lb. of dried fruit. *Apricots* and *peaches* must be thoroughly ripe and well coloured before being gathered. They are then pared, halved, and stoned by simple appliances, and placed on wooden trays cut side up. Drying takes five or six days in the sun, and is often preceded by sulphuring. As neither of these fruits are grown in Great Britain to any extent, there is considerable demand for the dried articles. Passable jam can be made from dried apricots, the proportions being 2 lb. of dried apricots, 5 lb. of sugar, and 8 pints of water. The apricots are covered with water for five minutes and drained, 8 pints of water being then added and allowed to remain in contact for 12 hours. Next transfer to an enamelled pan, boil for five minutes, add the sugar, again boil for fifteen minutes, and put into pots.



1. EUREKA APPLE-PARING MACHINE
(Sprague Canning Machinery Co., Chicago)

Canning and Bottling. Canning fruit is distinctly an American process. The English term would be *tinning*, but as the association of a metal with a food is apt to convey a bad impression, it is perhaps as well that the American term *canning* is used. Bottling of fruit is, of course, merely a development of canning, the primary reason doubtless being that glass is preferable to tin for food containers. The underlying principle of canning and bottling fruit is that the contents are sterilised, and then preserved in a hermetically sealed vessel. The temperature of 170° F. has been found to be the correct one to use in sterilising, but the time taken for this temperature to penetrate to the centre of the vessel containing the fruit naturally varies according to the size of the vessel and the kind of fruit which is being sterilised. The fruit must not be heated sufficiently long to cook it, hence care is necessary in the temperature employed, if successful bottled or canned fruit is to be produced. The "A. B. H." thermometer [2] is used to ascertain the sterilisation point of the interior of a bottle of fruit. A similar thermometer is also applied to cans. Fruit is canned in either water

or syrup. If syrup be employed, it is poured over the fruit as it boils, and consequently the time taken for sterilising is shorter. The general formula for canning fruit is as follows: Carefully select and prepare the fruit, place in the tins, and cover with cold or boiling water; seal the tin so that it is air-tight, and sterilise (or "process," as canners generally call it). The average times are: For small fruits, such as cherries and small plums, pint size cans, 8 minutes; quart size, 10 minutes. For large fruits, such as peaches and apricots, pint size, 10 minutes; quart, 12 minutes. These are for fruits with the stones left in. When the stones have been removed a shorter time is required, as the heat is conveyed to the interior in a shorter time; for pint cans, 6 minutes, and for quarts, 8 minutes are average times.

Preliminary Treatment for Preserving. Apples and similar fruits require paring and coring, as for making dried apples, but are not sliced. Pack as tightly as possible in the containers, fill with boiling water, seal and process. The time required is that given for stoned fruit. A difficulty met with in canning apples is the discoloration of the fruit. To obviate this some makers put the apples, after peeling, into a solution of sodium sulphite (1 oz. to 4 gallons of water), or a solution of alum of the same strength. When syrup is used, it is of the strength of 18° B., and is often flavoured with lemon.

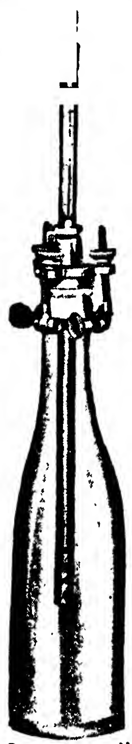
Pears are treated in a similar manner to apples, but are often more difficult to keep white. If the result desired be not obtained by the treatment given above for apples, the peeled and cored pears are exposed to the gas given off from burning sulphur for three or four hours.

Cherries have their stones removed by means of a *pitting* machine, are then put into bottles, covered with water, sealed, and processed. The cherries used should not be ripe, and the water employed for filling the bottles is generally coloured with cochineal, as the public prefer a brightly coloured product.

Greengages are pricked to prevent bursting, a silver or copper needle being employed. The water is often tinted green with a little emerald green. Plums are pricked, but no tint is needed.

Gooseberries are bottled when green.

Apricots and peaches are cut into halves and pricked, the stones also being removed. Syrup is always used for these fruits. Whole apricots are also canned.



2. "A. B. H" THERMOMETER

Rhubarb is bottled when tender and young. It is cut into pieces about 1½ in. long. Water is used in the bottles.

Bananas are bottled in syrup to which glucose has been added in place of sugar. The syrup is generally flavoured with vanilla or lemon, and to improve the taste, a little citric acid is added.

Red currants are removed from the bunches with a nickel, silver, or celluloid comb.

Blackberries require very careful picking over to remove leaves and refuse. For this purpose they are spread out on a table in front of the operator, a good light being essential.

Raspberries and strawberries are not successfully canned unless they have been previously candied—that is, if it is desired to retain their shape.

Pineapples are peeled by machinery and sliced, care being taken to remove all the "eyes." This fruit takes about two hours to process, at the temperature of boiling water, on account of its bulk.

Crushed fruits, so much used for soda fountains in the United States, are prepared by crushing or grating the fruit, which is then heated with boiling syrup at 28° B. for three minutes, then transferred to tins or bottles, and processed for a time varying from 10 minutes for pint containers, to 40 minutes for gallon tins.

Pulping. Fruit pulp is fresh pulp preserved without sugar; it is, in fact, a sterilising process of keeping fruit. Large quantities of fruit pulp are imported into Great Britain, and used for making jam. All the apricot jam made in Great Britain is necessarily made from imported apricot pulp, as but few apricots are grown in this country. Pulped fruits are a little inferior to ripe fruits for jam-making, and hence pulps are only used in medium and cheap jams. The difference, however, is mainly in appearance, and does not affect the wholesomeness of the product. The addition of colouring matter to jams made

ance. Raspberry pulp is imported from Holland in casks, but the comparatively recent importations of raspberry and black currant pulps from Tasmania are in tins of superior quality. Raspberry pulp, also comes from Canada and New Zealand, whilst apricot pulp is made in California, France, Spain, and Italy, where the sunny climate makes apricot growing in the open air possible. Plum pulp is not imported, owing to a curious anomaly in the British Customs classification which brings it under the head of prunes, a dutiable import.

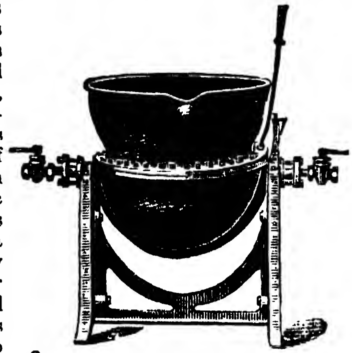
The process of fruit pulping is, in outline, to add 32 oz. of water to 20 lb. of the fruit, boil for five minutes, put into gallon or two-gallon tins, and process for from 2½ hours to 3½ hours (for gallon tins) at the temperature of boiling water. The tin should be lacquered to prevent possible metallic contamination and discoloration of the pulp.

Apricot pulp is made from ripe fruit which has been stoned, and a little more water is added than is given in the outline process above. The stones from the apricot are used for flavouring purposes, and should not be thrown away. Peach pulp is similarly prepared. Greengages are stoned, and in the preliminary boiling should not be violently stirred, as the fruit would be broken up too much. Cherry, strawberry, and black currant pulp present no difficulties, except that in the case of strawberries the preliminary boiling is limited to two minutes, on account of the soft nature of the fruit.

Jam-making. Jam is usually described as a conserve of fruit boiled down with sugar. There is no standard for jam. Each jam-maker has his own modification of the old formula—1 lb. of fruit to 1 lb. of sugar—the test of a good product being the appreciation of the purchaser. It is, of course, understood that wholesome ingredients must be used in every case. The employment of wet or damaged fruit for jam-making brings in its train a multitude of consequences which soon injure a jam-maker's reputation. The solidifying property of jam is due to the sugar and to the pectose contained in ripe fruit. The pectose, by boiling with vegetable acids, such as are also contained in the fruit, yields a product known as *pectin*, which possesses solidifying power like gelatin. Prolonged or violent boiling

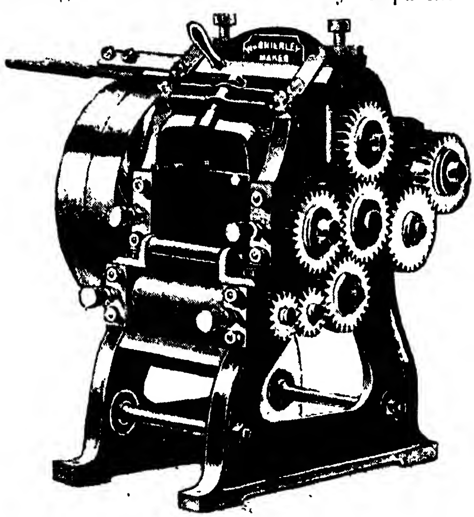
destroys the pectin, and hence impairs the solidifying power of the jam. On the large scale, steam pans [3] are used.

The general formula given above is the one on which the manufacturer founds his process, except that the boiling, which in the case of domestic manufactures may be up to two hours, is by steam pan process cut down to 15 or 20 minutes, the product being superior as regards flavour and appearance to the domestic article. Water is added in the same proportion as given in the pulping process above, and crystal sugar, equal in quantity to the fruit, is added, the mixture being boiled to dissolve the sugar. The contents of the pan are stirred, and if glucose be used, it is added in place of part of the sugar. The second or medium grade jam is made from fruit pulp, and a cheaper grade still is made by boiling fruit pulp 100 lb., sugar 30 lb., and glucose 70 lb., till dissolved, and adding towards the end of the process 1 lb. to 1¼ lb. of agar-agar dissolved the smallest quantity of water. The jam is poured into the earthenware or glass pots direct from the pan, and when the product has set, the surface is covered with a disc of paraffined paper, previously dipped in brandy or solution of salicylic acid. The wet parchment cover is stretched over the top and fastened so as to exclude air.



3. STEAM PAN FOR JAM-MAKIN
(William Brierley Ltd , Rochdale)

The Making of Special Jams. Strawberry jam is made from the freshest fruit, for if the strawberries stand over-night the colour of the jam is not so good. The Wisbech district, Kent, and Cornwall are the strawberry-growing parts, the Cornwall strawberries being the earliest in the market. Raspberries are grown extensively near Yarmouth, and at Blairgowrie. The crop of raspberries of late years has been poor, but it may be mentioned as a hint to growers that Maclaren's Prolific and the Antwerp raspberries are the ones which stand the climate best. Raspberry jam is a difficult one to set, and for this reason it is necessary to add a portion of gooseberry or apple jelly. Black currants come in large quantities from France, Holland, and Belgium, and on account of the ravages of the black currant "mite," imports of the fruit are necessary to meet the demand. Blackberries are preserved with apples, and such jam is in increasing demand. The blackberry crop is a difficult one to get picked, and fetches from £10 to £20 a ton. As regards plum jam, although plum pulp is not imported, for reasons stated above, immense quantities of plums reach this country from the Continent, in seasons of scarcity coming even from so far afield as Hungary. French and German plums come in some three weeks before the English plums are ripe for the market, but are not superior to English fruit. The advantage which foreign fruit enjoys over home grown is that large quantities of a particular kind of plum—such as the Zwetchen—can be obtained, whereas the English plums are from various kinds of stock. When home-grown plums are plentiful the foreign article cannot be profitably imported, as it costs £7 10s. a ton to import foreign plums, and an English grower is satisfied to get £7 in times of plenty. Greengages nearly all come from Cambridgeshire. Damsons are very largely grown near Wrexham for jam purposes, and although the popular taste has shifted from damson to plum jam, there are still large quantities of damson jam sold in Lancashire.



4. HOME-MADE MARMALADE MACHINE
(William Brierley, Ltd., Rochdale)

Kind of Sugar Used. In manufactured jam there is about 55 per cent. of sugar. The sugar may be either the product of the sugar cane or the beet. [See SUGAR.] There is practically no difference in the respective values of these sugars, so that the cheapest should be used. Glucose has been used by some manufacturers since 1864, but it is only in comparatively recent years that the use of glucose has been recognised as beneficial in jam-making. From 10 to 20 per cent. of glucose in jam prevents candying or granulating of the sugar when jam is kept, and besides yields a jam that is thinner and better liked by the public. When sugar is boiled with a weak solution of a vegetable acid, it is changed into "invert" sugar, then into dextrose and levulose, and finally into glucose.

Jam Colouring. As has been noted in the section devoted to pulping, the colour of the product is impaired, so that when made into jam a colouring matter is needed. Pink is obtained by the use of carmine (the active principle of cochineal) and a wine red by means of cudbear.

Aniline dyes, rhodamine and rosaniline are used, the quantity needed being but 5 or 10 grains in a hundredweight of jam. The colour is added in solution during the early part of the process of jam-making. As yellow colours, sometimes added to apricot jam, saffron yellow and auramine (aniline dyes) are used. In regard to the use of preservatives salicylic acid is employed in the proportion of ½ oz. to 1 cwt. of jam. It is added in the form of powder at the beginning of the process, the boiling of the jam being sufficient to ensure mixing. Owing to the minute quantities of the aniline dyes required no harm results from their use.

Fruit Jellies. Fruit jellies are transparent preparations of the juices of fruits, and are used to supply or make good the deficiency of the setting power of raspberry, strawberry and black currant jams. Some jellies are, however, largely used in place of jams, while red currant jelly has a special purpose in the *cuisine* as an adjunct to roast mutton and hare. The fruits from which jellies are mostly prepared are apples, gooseberries, grapes, black and red currants, and blackberries. The process is to mix three parts of fruit with one part of cold water, and boil. The mass is then transferred to filter bags and the juice is finally heated to boiling point and poured into stone jars which have been previously scalded to destroy fermentation germs. Fruit jellies are made by adding to each pint of juice a little over a pound of sugar and boiling till a small quantity of the product, removed and cooled on ice, sets to a jelly.

Marmalade. Marmalade is an orange jam, although originally the name was applied to a quince jelly, *marmelo* being the Portuguese for quince. It is now rarely made from quinces, but oranges, lemons, and grapes are used. Originally marmalade was made with honey, but now sugar and glucose are the bases employed. Orange pulp is imported from Spain for the use of marmalade makers. Machines are sold for the special purpose of cutting up the orange and lemon peel. A good *domestic marmalade* is made by using both bitter and sweet oranges with lemons. For instance, 6 bitter oranges, 3 sweet oranges, and 2 lemons may be taken, the peels being removed, with a minimum of white, cut up and boiled with 9 pints of water until soft. The rest of the fruit is pulped and the juice expressed, and in the mixture of juice and peel infusion 9 lb. of sugar is dissolved, and the whole boiled until jellying takes place on cooling a little of the mass. For making marmalade on the large scale, oranges are peeled, freed from pips, the peel sliced and cut up in pieces by a machine [**4**], and the rest of the orange reduced to a pulp; to 20 lb. of this pulp are added 30 lb. of sugar and ½ gallon of apple juice, the cut-up peel introduced, and the whole boiled slowly for an hour. After this further boiling is given at a more rapid rate till the product jellies on cooling. It is obvious that the oranges may be mixed, as in the recipe for domestic marmalade. *Orange marmalade* of the jelly class is made by excluding the orange pulp, using only the juice. A French recipe is as follows: orange juice, 5 pints; apple juice, 15 pints; syrup, 10 pints; sugar, 5 lb; finely sliced orange peel, 5 pints. These ingredients are boiled together till the marmalade sets to a jelly on cooling. *Grape marmalade* is really a fruit jelly, and is made according to the method described in the section devoted to fruit jellies.

Candied Fruits. Candying is a refinement of the preservers' art, and is applied to cherries, strawberries, greengages, small oranges and pears, to lemon, orange and citron peel, and to angelica. The fruits are prepared as for bottling and finally dried on trays made of white willow. A stoneware tank is employed, the fruits being packed in it and covered with weak syrup. After being in the syrup over-night the syrup is withdrawn by means of a stopcock at the bottom of the tank and concentrated by boiling and adding more sugar from, say, 20° B., at which it was used first, to 22° B. This syrup is then poured over the fruit and left for two or three days, drained off and again concentrated, the process being continued till the syrup registers 33° B., when it is drained off and the fruits taken out and dried slowly in a warm room. Finally, if the fruits be not covered with fine crystals of sugar they are crystallised by pouring over them, on a wire tray, a syrup of 33° B. strength, made from pure sugar, drained and dried. *Glacé fruits* are produced by giving the fruits at the end of the syruping process a few minutes' boiling in syrup and removing them to a wire tray to dry slowly. A small proportion of glucose may be added to the syrups used in candying fruits, and colouring matters may be introduced if needed. A hot process is also employed in which the fruits are boiled with the successive syrups. Besides being eaten for dessert, candied fruits are used for preparing superior kinds of jam. Candied strawberries and raspberries are excellent when made into jam with apple juice. Candied cherries are covered with maraschino-flavoured spirit to make "cherries in maraschino," and Wiesbaden fruits are candied fruits put up in strong syrup. For testing the strength of the syrup hydrometer [**5**] is employed.

5. HYDROMETER

The Factory. The ideal arrangement of a factory is such that the workmen are kept employed all the year round. Hence, factories which make jam should tin vegetables and make pickles to fill in slack months. It is, consequently, difficult to give trustworthy estimates of the cost of equipping a factory until the extent of the trade to be done is stated. The machinery for a small factory costs from £150, the capital outlay depending upon whether certain branches of the canning business are to be entered. *Can-making machinery*, for instance, is installed in large American canning factories, such installation costing about £100. Some of the costs of machinery used in canning are stated below to give the reader an idea of the expenditure in fitting up a factory.

Copper jam-boiling pans, suitable for working at a pressure of 70 lb., and with a capacity of 45 gallons, cost £15.

Tanks for bottling fruit are made of iron with false bottom for standing the bottles on, under which is the heating coil. The cost of a tank 7 ft. long, 2 ft. 9 in. wide, and 18 in. high, is £13.

Apple-paring machines cost £1 to £5, according to the pattern. An *apple slicer* of simple design costs 16s., the more complicated varieties running to £5.

A *marmalade machine* for stripping the white from orange peel and cutting into strips costs from £10 to £20.

An *hydraulic press* for extracting the juice from apple pulp by hand power entails an outlay of £50; for £5 extra it can be adapted to power.

Platform scales for weighing large quantities of fruit or sugar cost £4.

Horizontal boiler complete costs from £100 for a 10 h-p. boiler.

Hydrometers for testing the strength of syrups cost 4s. 6d. each.

Thermometers for taking temperature of water, etc., cost 10s.

Factory trucks cost £1.

Hoist, of a capacity of 1,000 lb., costs £10.

Soldering irons cost from 2s.

Peeling knives cost 3s. 6d. a dozen.

FRUIT PRESERVATION *concluded; followed by* FISHERIES

THE BRANCHES OF INSURANCE

Fire, Accident, Burglary, and Marine Insurance. Employers' Liability. History of Lloyd's. The Principles of Underwriting. Treatment of Claims

Continued from page 4733

By W. A. BOWIE

FIRE INSURANCE

We have now finished with Assurance work and must turn our attention to the Insurance branches of the profession. It should be explained that the word "assurance" is usually applied to life policies, while "insurance" is used for all other kinds of policies.

A company called the Fire Office was started in 1680, with premises at the back of the Royal Exchange, provided with "a considerable bank of money and a fund of free land." Since then fire insurance has steadily grown in importance, until there are now many companies doing an immense business, with millions of funds held in reserve against any possible conflagration.

Settlement of Claims. Fire insurance on payment of certain premiums is strictly an indemnity for actual loss sustained through fire and lightning to an amount not exceeding the sum insured. The amount of the policy is not necessarily the figure which will be paid by the fire office. It is not intended that the insured should make a profit through a fire, the object being rather that he should only make good his monetary loss. It is a great safeguard for the fire office that the insured is aware that he himself is likely to suffer inconvenience through the disturbance which a fire must involve. The amount claimable is regulated by the value of the property at the time of the event, irrespective of what was the original cost.

This is quite a different practice from that which holds in marine insurance. If a ship is insured for £30,000 and goes to the bottom, the underwriters must pay for a total loss, even if the ship had depreciated considerably. If a fire office paid more than a fair indemnity it is held that the practice would prove a source of temptation and would endanger human life and property, while the rates of premiums would require to be largely increased. Even as it is, the numerous cases of arson amongst a doubtful class of insurers show the necessity on the part of the offices for taking stringent means to prevent bogus insurances.

A young man who thinks of entering a fire office may, by a little influence, or by a carefully written and well expressed reply to an advertisement, secure a situation. He should remember that as yet he knows little. Before him lie many difficult problems. He will be expected to acquire some knowledge of building construction and plan drawing, chemistry and electricity. He must, while at work in his office, learn all he can about fire tariffs, and the different processes of manufactures. He must read up the law relating to fire insurance.

Proposals and Policies. Probably a junior's first duties will be to write out in appropriate forms particulars of the various fire assurance orders which arrive each day. This will make him acquainted with the many forms of risk, and he will thus get to know the various rates of premium that are fixed for each kind of property. He may then be set down to prepare policies for the more simple kinds of risks, such as insurance on private houses and furniture.

Policies covering shops will be somewhat more difficult to undertake, because of the various hazards incidental to each trade. Special clauses require to be inserted in the case, for instance, of an oil and colourman who keeps paraffin oil and turpentine on the premises. Later on the clerk will be asked to write *floating policies*—that is, policies covering goods which may be distributed over several warehouses, and be constantly moved about from place to place. A huge factory may be the next risk to be dealt with, and here there may be a very extensive schedule with varying sums and rates of premium for each portion of the risk. And so the beginner will be led through an endless variety of work, which at first will seem bewildering. Perhaps after a year at these duties, an opening will occur in another department, and our junior will pass on to gain further experience.

Risk Books. The property of the central portions of a great town will be set out in books of maps and streets. It will be the duty of the Risk Book Clerk to watch carefully that too great sums are not accepted on any one block, and to enter every risk taken up, so that it may be seen at a glance how much insurance has already been accepted in one area. When an insurance lapses through non-payment of premium, the risk must be deleted, and no effort spared to see that the company is not, through oversight, involved in heavier claims than were ever contemplated in the case of one fire, however great.

Tariff Offices. An elaborate system of tariffs has been arranged by combination among the great fire insurance companies. A knowledge of the schedules drawn up to govern the rates for docks, warehouses, and factories will take years to acquire, and the student will need all his powers of memory to grasp the bearings of each separate tariff.

The following questions which have appeared in the examination papers of the Federation of Insurance Institutes will show how elaborate and exhaustive is the system of rating, and how necessary it is that the chief officers should agree upon certain guiding principles which it

will be the duty of younger members of the staff to acquire and apply in the infinite variety of fire risks which will come before them.

(1) What rate would you charge a cycle dealer (*a*) with, and (*b*) without oils? Give the warranties in full.

(2) What rate would you charge a chemist and druggist (*a*) with, and (*b*) without oils? Give the warranties in full.

(3) What rate would you charge a draper, other than woollen, with one hundred assistants (ten of whom are employed in the restaurant or tea-room), and what extra would you charge if he also carried on the trade of a chemist and druggist?

(4) A draper decides to carry a stock of house furnishings, domestic ironmongery, and hardware. State what extra rate is chargeable, and quote the tariff on the point.

(5) Large premises in which there are combined trades in one tenure communicate throughout. Insured desires to reduce the rate, but wishes to preserve a communication. What would you recommend?

(6) In the case of a sprinklered building, state:
- (*a*) The discount for automatic sprinklers.
- (*b*) Does this include discount for ordinary fire appliances?
- (*c*) What is the minimum net rate?
- (*d*) To what items would the average clause apply?

(7) What is the rule as regards payment of a fixed percentage for interest on pledges in a pawnbroker's shop in the event of fire?

(8) What is the rule for goods in a strong-room? And define the term "strong-room."

(9) What discount may be allowed on standard fire-resisting buildings and on what conditions? Give the minimum net rate for such buildings.

(10) Mention some combinations of trades which entail an additional rate of 2s. 6d. per cent.

The Surveying of Properties. Every fire office has its chief surveyor and assistants, who are called upon to visit factories and other dangerous risks. No experience could be more valuable, and if a young man is fortunate enough to be drafted for a time into the Surveying Department, it will be one of the best chances in his life. Accompanied by his chief he may have opportunities of visiting such risks as bleaching works, cotton spinning mills, collieries, and boot and shoe factories. He may assist in preparing a plan of a mill accompanied by a report giving full details as to height and occupation of buildings, and also as to any surrounding hazard.

It will be his duty to learn from his principals, and later on to be able to fix for himself, the rate which is considered adequate to cover the various risks. Such knowledge and practice will be of immense service to a youth if later on he becomes a branch manager of a fire office, or if on some memorable day of his life he be appointed general manager of one of the great offices.

An earnest student of his profession will lose no opportunity of visiting, perhaps as one of a party arranged by an Insurance Institute, factories which are not at the moment brought before him for insurance, but which, at any future time, he may be called upon to survey, or to insure upon the report of some surveyor.

Here, for instance, is a question from an examination paper, which will show what a wide field there is for study in this connection: "How should the structural arrangements for a steam corn mill and grain warehouse be planned in order to secure the most favourable terms under the corn mill tariff?"

Guarantee Department. It being evident that a company securing an order to insure a very large block of property cannot cover all the risk itself, it is necessary that a system of re-insurance exist between the offices. A clerk must, therefore, master the proper mode of procedure in giving off risks, and in the acceptance of risks from other offices. He will also get to know the rules governing the issue of request notes, followed by formal guarantees. He will find that a code of honour is in vogue, as well as a system of rules.

The practice of re-insurance is a useful one, whether considered from the point of view of the offices or their clients. In addition to the obvious benefit of having a limit to the liability an office may undertake on one risk, the fact that the company giving off risk must furnish full knowledge of the case ensures that all the important companies are kept in possession of the current tariffs and the most modern methods adopted by each. Again, the insured is saved trouble by getting his proposal, however large, dealt with at one office instead of having to approach several with portions of the risk; while he can feel confident that a great fire, which might ruin any one office and so render his foresight vain, is not likely to have such consequences under the guarantee system.

The office accepting portions of the risk takes cognisance of the amount for which the ceding company makes itself responsible, and generally is careful not to accept more than is held by the office giving off the risk. An offer of business coming from one well-conducted office to another is usually regarded as a sufficient recommendation; but each company considers itself at liberty to vary its acceptance as it thinks proper. A large office may take up double the amount retained by the original company if the latter be a small one working under careful limitations.

Non-tariff Offices. There are a few fire companies which have not joined the Tariff Association, and which profess to do business by taking each risk on its merits without reference to the rates fixed by the great combination of tariff offices. Many companies start by adopting non-tariff principles, but few make a great success on this basis. The tariff offices are bound not to deal with the non-tariff, and so the latter are shut out from the great benefit and convenience of being able to re-insure freely or to profit by the experience of the tariff companies. As a matter of fact, the non-tariff offices' rate is often fixed by finding out what the tariff company charges, and allowing in some cases a

deduction where they think special circumstances justify it.

The tendency of insurers is to go only to the non-tariff offices when dissatisfied with the rates of the tariff companies, so that there is great danger of the former not getting the pick of the better class risks. It frequently happens that offices outside the combine, after being established for some years, apply for admission among the tariff companies, and the loss experiences of the non-tariff offices have certainly not, as a rule, been of a very happy nature.

Insurable Interest. A valid insurance contract presumes a real risk of loss in all cases. Mere speculation upon events by which the proposer is not affected will not suffice. Moreover, the matter in which the insured is interested must in itself be legitimate or the claim will not be sustained. The nature of the interest in the risk should be inserted in the policy, and where this is short of sole ownership the facts should be definitely stated also. The extent of interest is confined to its actual amount or value, and no greater sum can be recovered.

It frequently happens that three separate parties have an interest in one building—the freeholder, the leaseholder, and the mortgagee. It is sufficient to have the interest of each party noted on the policy without specifying the individual amounts at risk.

Fire Claims. An important department of fire insurance work is connected with the settlement of claims. Few outsiders can realise the immense amount of trouble which must be taken to arrive at the sum to be paid by way of indemnity in connection with a great fire, while even small claims may give rise to questions requiring careful attention and the exercise of considerable tact. A claim register is kept in which all claims are at once entered on the first intimation of loss. If the fire is at all of a serious nature a fire assessor will probably be appointed. He is a man—not generally in the full employment of any one company—who makes it his profession to estimate the extent of the damage and bring about an amicable settlement with the insured. Where several fire offices are interested in the same risk, it is usual for officials from each office to meet by appointment, fixed by the assessor or by the leading office—the company having the largest amount at risk. The proportion payable by each company is, after consideration of the assessor's report, agreed upon at this meeting.

Arbitration. Arbitration is resorted to in the case of a disputed claim, where the amount of the loss cannot be agreed upon. There may be one arbitrator, acting for both office and claimant, or there may be two, one chosen by the company, and the other by the insured. In the latter case an umpire must be appointed, so that, should the arbitrators be unable to agree on a figure, he may give his decision. If notice of election of arbitrator for either party be given, and none other be appointed within a certain time, the one elected can act alone and as if agreed on by both parties. The award is regarded as conclusive, whether given by a sole arbitrator, by two arbitrators in agreement, or by an umpire.

The greater part of the profession has of necessity to be learned by actual experience, although there are certain books, already mentioned, which have been recognised for years as the leading authorities on the subject. This being so, it is obvious that the utmost that can be attempted in these articles is to point the road along which the student has to travel, making his progress by the way as easy as possible.

One of the best tasks an intelligent junior can set himself will be to pass—not all at once, but one or two at a time—the examinations set by the Federation of Insurance Institutes, held annually in April. As these examinations are not compulsory, we do not give details, but intending candidates may obtain full particulars from the Federation, 9, Albert Sq., Manchester.

Specimen Examination Questions.

1. Describe the various stages in transacting guarantee business up to the issue of the guarantee policy.

2. What openings in a parting wall are not to be regarded as communications, and what is meant by the term "fireproof compartment"?

3. State what you consider to be the main fire hazards of tanneries.

4. What special danger is there in exposed iron or steelwork of so-called fireproof buildings, and how may it be obviated?

5. Summarise concisely what constitutes insurable interest.

6. Give a brief but clear statement of the reason for the adoption of the Average Clause in Mercantile and Industrial Insurance.

7. What are the chief points to be observed in the inspection of an installation of electric wiring in a private residence?

8. Name four chemicals in extensive use that are likely to cause organic substances to ignite or explode, and give short details as regards two of them?

9. Reply to a policy-holder having considerable insurances on farm buildings, agricultural produce, and livestock who complains that no concession in premiums is made to him, although his premises are fitted with electric light (dynamo driven by oil engines), and he has some efficient extinguishing appliances.

ACCIDENT INSURANCE

Large numbers of men are engaged in that branch of insurance which may come under the term Accident Insurance. Beginning with insurance for the purpose of giving protection to a man who might meet with injury to his own person, especially through railway accidents—at one time a much more serious risk than now—the business has developed in many unlooked-for directions.

Accident business may to-day be divided into the following departments: (1) personal accident; (2) employers' liability; (3) burglary; (4) horse, cattle, and carriages; (5) plate-glass; (6) sickness; (7) general contingency.

The junior clerk who finds himself installed in a well-managed accident company may assure himself that there are great possibilities before

his office. The introduction of steam first brought the need for this kind of insurance prominently forward, and since then the use of electric power, and the risks attendant on the driving of motor-cars and the riding of motor-cycles of all kinds, have added new terrors to life, and provided a fresh field to be exploited by the insurance company.

Personal Accident. Not so long ago, a personal accident policy only covered a sum at death, certain sums in the event of loss of limb or sight, and a weekly allowance in case of temporary, total, or partial disablement. More recently, a long catalogue of infectious diseases and certain well-defined forms of illness have been included, until an accident policy can hardly be distinguished from one for general sickness.

The experience of the companies confining themselves to granting general accident policies, with certain defined diseases added, seems to show that the field is somewhat restricted; yet in this department alone there is scope for the exercise of great wisdom in accepting suitable classes of risk and keeping careful watch as to moral hazard and cases of doubtful character. Anyone without clear means of subsistence should be refused a policy. This action may save the company a great deal of future trouble from a man who might be guilty hereafter of malingering, or trying to secure by false pretences compensation to which he was not entitled.

The settlement of claims is sometimes a matter requiring great tact. The insured may wish to be paid handsomely for the pain which he has suffered rather than according to the amount specified in his policy. If a clerk is called upon to settle with unfortunate claimants, it may tax his ability considerably to arrive at a sum which will please the policy-holder and at the same time satisfy the manager of his company that a settlement which is not excessive has been made. Here brain and tact come once more into play.

Burglary Insurance. Within a few years burglary insurance has developed into a branch of considerable importance. Every prudent man protects himself against the loss caused through burglary, housebreaking, larceny and theft, and, in the case of business premises, against burglary and housebreaking only, in the same way as he makes provision against loss by fire. The rates of premium and the methods adopted in the settlement of claims do not greatly differ in the two departments. In burglary business, however, there are special hazards which directors and managers are sometimes called upon to consider, such as the insurance of jewellers' shops and other business risks where goods of considerable value in small bulk are stored.

The moral hazard, too, in this particular department of insurance is greater than in any other branch, and the companies accepting risks have to exercise considerable discretion in their selection if profitable underwriting is to be the result. A cautious manager will no doubt be able to accomplish this, but, on the other hand, a responsible official of too sanguine temperament may, by expensive management and the acceptance of doubtful risks, bring his company into such a position that amalgamation with a stronger office becomes an absolute necessity.

Employers' Liability. The Workmen's Compensation Act of 1897 gave an immense impetus to this class of business. It is now the law of the land that an employer is liable for accidents caused by his machinery whether he was to blame or no; and workmen are entitled to compensation for any accident they may sustain while in their master's employ, provided no gross negligence can be proved against the worker.

After a period of a great deal of rate-cutting, during which quite a number of small accident companies collapsed, a fair basis for rating risks has been somewhat generally agreed upon. It is much to be hoped that a still closer bond of union will prevail among employers' liability companies. The business promises to be almost as great as that of fire insurance some day, as the tendency is for legislation to bring more and more kinds of occupation within the scope of the existing Acts. At the present time certain amendments to include domestic servants and others are under consideration.

It will be the aim of a clerk to learn the various classes of hazard to which people of all ranks—especially workmen—are liable. As the fire insurance clerk will visit as many mills and factories as possible for the purpose of deciding for himself what are the risks of fire, so the employers' liability man will endeavour by the same means to estimate the risks to life and limb which are likely to result from the use of machinery and chemicals. Some specimen examination questions are subjoined which will suggest a few of the considerations to be reckoned with in the departments of Personal Accident and Employers' Liability Insurance.

1. State what general principles you would lay down for dividing occupations into three classes for personal accident insurance.

2. Assuming proposers described themselves as under-mentioned, what further information (if any) would you ask for before classifying the risks: master baker, licensed victualler, farmer, builder, accountant, cattle salesman?

3. Give reasons why most accident companies refuse to grant personal accident policies to jockeys, steeplejacks, divers, coal miners, quarrymen, experimenting chemists, etc., even though the persons engaged in such occupations be willing to pay a higher premium than that charged Class III. risks.

4. (*a*) Under the E.L. Act, 1880, a workman is defined as "a railway servant, and any person to whom the Employers Workmen Act, 1875, applies." What is the definition of a workman given by the last-named Act?

(*b*) What is the definition of a workman given by the 1897 Act?

5. Within what time must notice of an accident be given to entitle the claimant to compensation:

(*a*) Under the E.L. Act, 1880?

(*b*) Under the Workmen's Compensation Act, 1897 ?

6. What particular circumstances must be present in any particular job to bring a builder under the Act of 1897 ?

MARINE INSURANCE

The student will find that as in fire so in marine insurance there are radical differences in the governing principles from those that were brought to his notice in life insurance. Briefly put, marine insurance is a contract by which the insuring company, or underwriters, as they are often called, undertake, in consideration of a certain premium, to indemnify the insured against any loss or damage from some specified risks. In a life assurance contract, if it be continued, a payment by the insurer must be made eventually, but this is not the case in marine insurance. If, however, an element of certainty be absent, the shrewdness and practical experience brought to bear by underwriters and marine company officials upon statistics covering a long period of years result in the fixing of reasonable rates for the different classes of risk. When it is remembered how greatly concerned with shipping our country is, the importance of marine insurance must be apparent. If, further, we reflect that our oversea commerce is world-wide, and that a loss may occur in any part of the globe, it will be seen how necessary it is that a large mutual trust must be shown by all the parties concerned. In this connection the reputation of Lloyd's for prompt and honourable dealing has proved of great influence; and as their name has now become synonymous with maritime business, this influence is felt all over the world.

History of Lloyd's. A coffee-house which was kept by Edward Lloyd, in the latter part of the seventeenth century was greatly in favour with seafaring men, partly, perhaps, on account of its locality and partly, no doubt, by reason of the enterprise of its proprietor. A considerable amount of business used to be transacted in coffee-houses, and in the case of Lloyd's this became mostly associated with shipping. Public sales of ships often took place at his tavern, and he instigated a far-reaching system of correspondence at ports in this country and abroad, by which means he was supplied, for the benefit of his customers, with news of the movements of vessels, and with other maritime information. In time, as one result of this devotion to shipping interests, Lloyd's coffee-house became the headquarters of marine insurance business, then carried on solely by private underwriters. Soon, enlarged premises were needed, and in 1774 Lloyd's, which by that date had become an association of underwriters governed by fixed rules, became permanently established at the Royal Exchange. The influence exerted by Lloyd's is not confined to marine insurance. In early times "wager policies," since prohibited by law, were effected, and recently the protection of bank deposits, such contingencies as the birth of twins, the scratching of a racehorse, the alteration of the income tax, have been insured. Fire risks are also undertaken, generally after considering the rate asked by the tariff offices. Even life insurances for short periods only are accepted, although it is doubtful as to the legality of members of Lloyd's so doing; but the insurance business done at Lloyd's apart from marine risks is very small as compared with maritime insurance.

Principles of Underwriting. The parties to a marine insurance contract have already been mentioned. The services of a broker are, as a rule, employed to bring the insuring company and insurer together. Underwriters at Lloyd's carry on business in their own individual interests, and with their own capital. No responsibility for their engagements rests upon the corporation. The risk in a case is undertaken by several members, each becoming liable for such portions as he sees fit to take up. Brokers effect insurances with the underwriters, either on their own account or for third parties. As a rule, the rates at Lloyd's are rather cheaper than those of the marine insurance companies, because the expense of conducting business at Lloyd's is very low. Two of the oldest companies, incorporated with peculiar privileges in 1720, are the London Assurance Corporation and the Royal Exchange Assurance Corporation. These, with Lloyd's, long enjoyed a monopoly of marine insurance, but the vast expansion of our seagoing commerce has justified the appearance of many later companies, some of which contrive to do a large and profitable business.

The Policy. A clerk will soon make himself familiar with the usual form of policy, which is based upon that adopted by Lloyd's, the latter being at one time used almost exclusively. There are several classes of policy. Among these may be stated voyage policies and time policies, in which property is respectively insured for transmission from one point to another, or for a certain period of time not exceeding twelve months; valued policies, where the amount at which the object insured is valued is definitely mentioned; open policies, where there is no such declaration, and in the event of a claim the burden of proof of value will rest on the insured. Floating and named policies are also in contrast, the latter containing the name of the vessel on which the risk is taken, the former furnishing no such name, and thus enabling an owner to obtain protection in the event of a loss occurring before he knows what vessel or vessels may carry goods shipped at a distant port. When in a position to do so, and within a certain time, he must, however, declare the name of the vessel or vessels.

The Policy in Detail. The wording of a policy will call for careful scrutiny by the student, since the fact that it adheres so largely to the language of a time long past, very different from our own, makes the settlement of complicated cases the more arduous a task. This, however, it should be said, throws into bolder relief the honourable spirit in which the principles of underwriting are conceived and invariably carried out.

Many of the words in the policy will be quite unknown to the beginner, and nearly every phrase will require study, and possibly explanation, in order to be thoroughly understood.

"Adventures and Perils," for instance, refer to "perils of the sea," the definition of which has been the subject of much judicial consideration. They do not include every accident liable to occur on a voyage, nor do they include every damage actually caused by the sea itself, since there is damage that is inevitable rather than accidental.

"Lost or not lost" is one of the old expressions, and is usually inserted in the case of insurance being effected while the vessel is at sea, the underwriter accepting the risk, no matter what may be the condition of the goods or ship at the time. The adoption of this clause, of course, presumes the good faith of both parties, for the assurer could not avail himself of the policy if he knew at the time of insurance that a loss had occurred, and the underwriter did not; nor could the underwriter retain the premium if he knew, and the insurer was ignorant, that the risk was then actually at an end.

The little words "at and from," which precede the description of the voyage, have considerable importance, and in order to fully apprehend their meaning, whether in regard to the ship or to freight and cargo, a knowledge of mercantile law, so far as it applies to marine insurance, is necessary. The same caution must be observed with reference to unusual words in the policy or *memorandum*, a safe interpretation of which can be ventured only with the aid of the law.

The voyage must be made in the proper course, as agreed by custom, from the port of departure to that of arrival. Deviation is permissible in special circumstances, such as to save human life, or to gain safety for the ship, and is provided for by a clause in the policy, and covered at a premium to be settled.

The term *jettison* means to throw cargo overboard, with a view to lighten the vessel in an emergency, and get her out of danger. Loss to the underwriter does not generally ensue in respect of any cargo other than that carried under deck, unless the custom of the particular trade warrant it. The jettison must be performed in good faith, under real danger, otherwise the loss would be avoided by the underwriter, and the act come under the definition of *barratry*. This means all wrong or illegal conduct against and to the injury of owners by master or mariners, even if done with no intention to injure them, or benefit master or mariners.

Losses. Losses are of two kinds—partial, when the subject insured is but partially damaged or an obligation to contribute to general average has arisen; and total, where the subject is wholly destroyed, or so damaged as to justify abandonment. Total losses are, again, divided into actual and constructive. The former takes place when the subject of the insurance is destroyed or so damaged as to become valueless, or practically so, or where the insured is irretrievably deprived of it.

Constructive total loss occurs where, although the subject is still in existence, it has suffered irreparable damage, or is in such a position as to be out of control of the assured or his representatives. Cases in point would be a vessel, perhaps quite sound, stranded on a desert coast, with no appliances for getting her off, or so damaged that the cost of repair would exceed her value when repaired. In such cases the owners would give notice of *abandonment* to the underwriters, thereby formally giving to them whatever may be left of the commodity to set against their payment of the claim. When a vessel meets with damage not too serious, if repaired, to enable her to proceed on her voyage, the captain may have to raise money to carry out the repairs.

Bottomry consists in pledging the ship, or the ship, freight, and cargo, as security for the amount obtained, which is to be repaid when the vessel reaches her destination. Should further disaster overtake the vessel, necessitating a new loan for repairs, the last bond has the prior claim; while, should a ship be lost subsequent to the giving of the bond, the lender loses his money. This naturally makes the interest on premium for bottomry very high.

Reference has already been made to general average. This arises where a voluntary sacrifice is made of the interests of one or more parties for the benefit of all. When the loss is not suffered for the general benefit, the term *particular average* is employed. A little thought will show that the distinction between these is no easy matter, and this, and indeed the whole question of loss, calls for a great degree of technical knowledge, in addition to experience and ability. The adjustment of loss, under a claim, to the merchant, shipowner, and underwriter respectively is entrusted to men of expert knowledge known as average adjusters or average staters, assisted by surveyors. The result is embodied in a document drawn up by the adjuster, and called *the average statement.*

An Insurance Clerk's Career. A promising junior can now see that there is enough in marine insurance to demand the exercise of all his talent. It will take a lifetime to acquire all the knowledge necessary to make a first-class expert. By diligence and enthusiasm in his work he should, however, be a valuable clerk in the course of a few years, and may hope some day to become an underwriter at Lloyd's, trusted by a number of well-to-do men with the use of their names as guarantors in connection with most of the risks which he cares to accept; or, he may eventually secure a position as underwriter to one of the great insurance companies, and have decisions to make regarding risks that may run to millions of pounds in a year. To sum up the whole, each junior must make himself well acquainted with every clause in a marine insurance policy, with the names of all the boats in the great steamship lines, and have a general idea as to which class of ship any one boat belongs on hearing her name and tonnage mentioned. He must train to become expert in the settlement of claims, and get familiar with the principles which underlie the treatment of the great variety of risks which are continually coming up for consideration.

INSURANCE *concluded; followed by* AUCTIONEERING AND VALUING

THE ART OF BREEDING

The Important Points. Improvements Effected in Breeding. Examples of Perfect Exhibition Birds. The Tendency to Degeneration. Selection of the Fittest

continued from page 4663

By Professor JAMES LONG

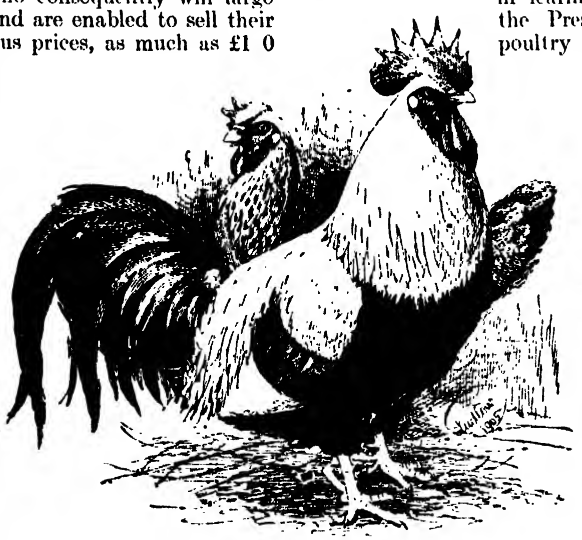
THE British poultry fancier, to give him his proper designation—that is, the man who breeds for fancy points, the real promoter and supporter of exhibitions of ornamental poultry, such as the White-crested Polish [6], as distinguished from utilitarian poultry, such as the Silver-grey Dorkings [7]—has evolved from very poor material a variety of colours, markings almost mathematical in character, and other points of beauty which are high testimony to his skill.

Poultry Exhibiting a Cheap "Sport." There is a love of sport inherent in most of us, and those who are unable to breed race and other horses, to exhibit cattle, to run greyhounds, or to adopt one of the many other sporting or rural hobbies, in tens of thousands of cases keep poultry or pigeons, which they exhibit for prizes with some constancy, and thus gratify their taste for one form of innocent excitement. There are many with little knowledge of the art of breeding who make a practice of purchasing specimens from more capable persons than themselves. It is the comparatively few who breed with success, and who consequently win large numbers of prizes, and are enabled to sell their stock at advantageous prices, as much as £1 0 not infrequently being obtained for a single fowl. There is no reason, however, why successful breeders should not be more numerous, and therefore greater gainers, both by sales and prizes, whether in the prize pen or in the sale of their stock.

Attending the Best Shows. Breeding is an art, and it may practically be based upon the principle that "like produces like." It is first essential that an intending breeder of prize poultry should thoroughly understand what he requires. He must learn to recognise to a nicety every point in both the male and the female variety which he selects for his purpose, and there is no better plan in order to master this detail than that of attending a number of the best poultry shows and of comparing every point in the prize specimens, not only with each other, but with the birds which are unnoticed by the judge, and especially with birds owned by himself, which he may take the precaution of exhibiting for this particular purpose.

6. WHITE-CRESTED BLACK POLISH

It may be essential to ask the advice and help of judges from time to time, and he may rest assured that both will be cheerfully given. It is essential, too, to learn which points are most easily lost, and which are most difficult to obtain and to fix. Nor must a novice be disheartened if he find that for a year or two, however good the specimens he obtains to form his breeding pen, a large proportion of his chickens are inferior, or, indeed, practically valueless for exhibition purposes. Loss of time and vexation, however, will be minimised if the greatest care is exercised in learning, either through the Press representing the poultry fancier or through judges of known integrity, from what quarter to obtain his first lot of breeding stock, for practically all depends upon its selection.

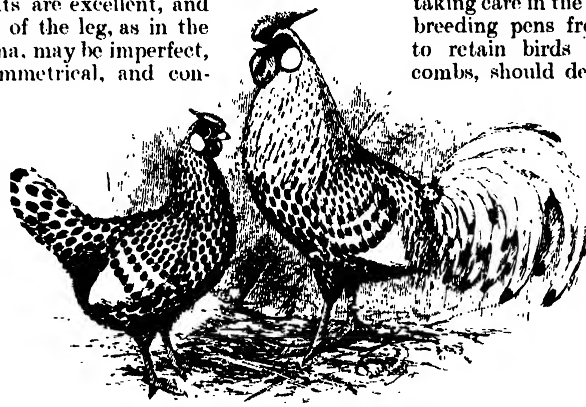


7. SILVER-GREY DORKINGS

Obtaining Accurate Advice. Most men are anxious, if they are owners of poultry, to effect sales to everyone seeking their aid; hence the importance of obtaining the counsel of independent judges who have nothing to sell, or who, still being breeders, are above taking any advantage of the ignorance of the novice. The common fault, even among

exhibition specimens, is that, however good some points may be, there are defects of a more or less marked character. In a yard of birds of a pure breed some specimens will possess one, two, or three points of great excellence, while others are sadly deficient. Again, some birds possess first-rate combs and good colour, but are defective in marking or deficient in size; or it may be that all these points are excellent, and that the feathering of the leg, as in the Cochin [9] or Brahma, may be imperfect, or the form unsymmetrical, and consequently distasteful to the eye.

The object of the breeder is, by the practice of selection, to reproduce in the progeny of his stock birds from year to year every point of excellence, so that they come as near to perfection as possible. It is needless to say, however, that perfection has never been obtained, and that it never will be. If it were possible, breeders would defeat their own object by their extraordinary practice of changing the fashion, and consequently one or more points in the different varieties, from time to time.

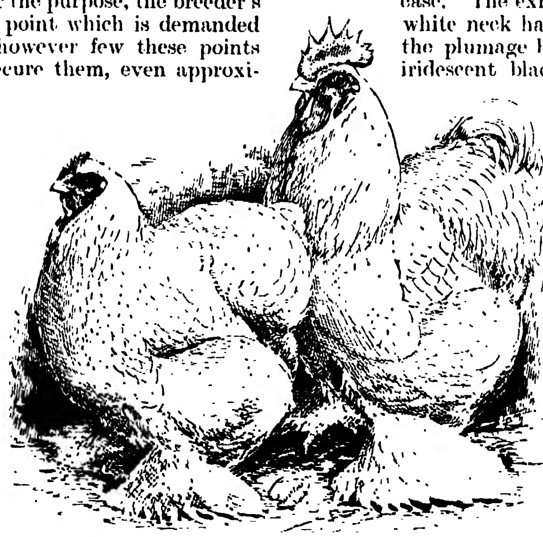


8. SILVER-SPANGLED HAMBURGHS

Points First to be Aimed at. In starting to form a strain from a group of stock birds selected for the purpose, the breeder's object is to fix every point which is demanded by the judge. But however few these points may be, he cannot secure them, even approximately, by attempting to obtain each and all from the start. He should endeavour, by the adoption of a pre-arranged rule, to fix two, or at the outside three, points before paying too much attention to others. We may take a Pencilled or Spangled Hamburgh [2, page 4661, and 8] as an example. The chief points in these varieties are the rose comb, the round kid-like white ear, the ground colour of the plumage, the marking, the legs, the face, and the form. To attempt to obtain all these points at once would be to waste time and to court failure. In this case we are taking old-fashioned varieties in which the various points are practically fixed, and therefore the breeder has something definite to work upon. Nevertheless, as the comb and the ear are of high importance—for unless both are excellent the chances of success in competition are very poor, however charming the colour and marking may be—it is possible to obtain breeding stock in which both are sufficiently good for the purpose in view; and therefore the breeder, while taking care in the selection of his future breeding pens from his own chickens to retain birds with good ears and combs, should devote extra attention to colour, marking, and symmetry. Like the comb and the ear, the colours of the legs and the face are practically fixed in all good strains, while both colour and marking are still more or less imperfect.

The average breeder, however, in seeking to obtain these points in approximate perfection, much too frequently includes the minor points we have named, and loses ground in consequence.

The Silver-pencilled Hamburgh. It may here be worth while to point out that pairs of birds as exhibited are not always bred from the same type of parent. We take the Silver-pencilled Hamburgh to illustrate our case. The exhibition hen possesses a white neck hackle, the remainder of the plumage being marked with fine iridescent black bars, or pencilling, as clear and mathematical as possible; her comb, ear, and legs match those of the male bird. On the other hand, the exhibition cock to mate with this hen possesses white body plumage—we refer to the exposed plumage only—with a tail of metallic black, each curved feather of which is edged or laced as accurately as possible with white. A perfect specimen of this variety is one of the greatest triumphs of the poultry breeder's art. It is obvious, therefore, that an almost entirely white male and a densely-marked female could hardly be bred from the same parents.



9. WHITE COCHINS

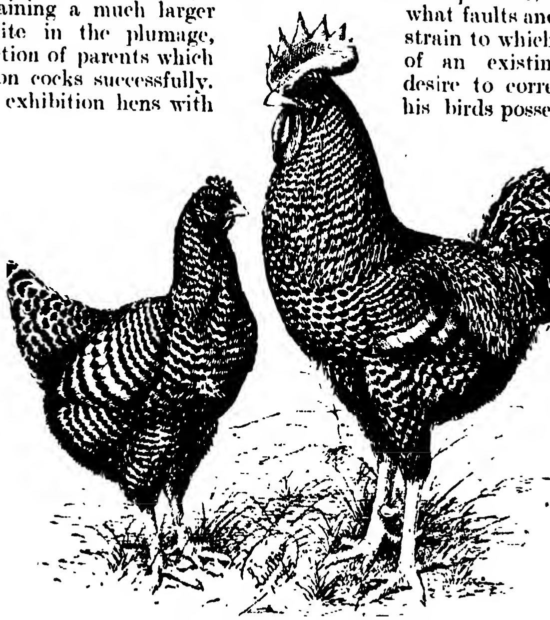
The Perfect Exhibition Birds. How, then, are these birds produced? For the production of the cockerels the male bird

in the breeding pen should be one of the most perfect exhibition birds that can be found, the exposed plumage being a clear, brilliant white, the sickle feather of the tail and the coverts well laced, the comb symmetrical, the ears round and white, the face a perfect red, and the minor points accurate. The hens to mate with such a bird should be bred like himself from an exhibition cock and from hens similarly bred. These hens are identical with exhibition hens, except so far as their marking is concerned. They are naturally imperfect in this respect, containing a much larger proportion of white in the plumage, and are the production of parents which have bred exhibition cocks successfully.

10. HAMBURGH ROSE COMB

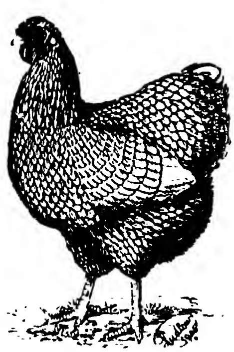
11. BRAHMA PEA COMB

We turn to the exhibition hens with the same query. How are they produced? Simply by mating exhibition hens as near perfection as possible with a cock bred in the same way. This bird, instead of being entirely white, the tail excepted, over the whole of the exposed body-plumage, displays a large proportion of black marking, which closely resembles the pencilling of the hens, especially on the feathers of the thighs, and even on the breast and tail. In a word, a cock used for breeding exhibition hens should match these hens as nearly as possible in the marking of the plumage, while the hens used in breeding the exhibition cocks, while not so closely resembling those birds, should be correspondingly lightly marked on the plumage.



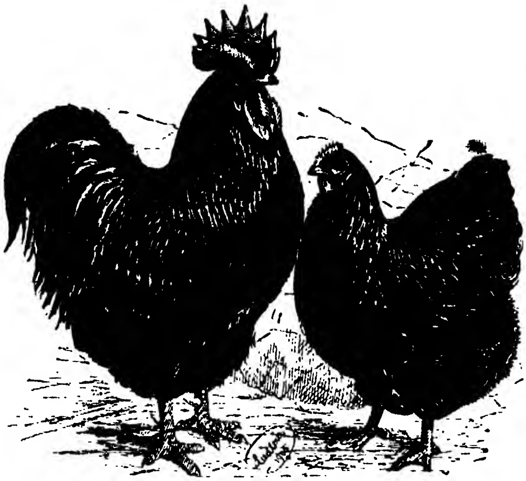
12. BARRED PLYMOUTH ROCKS

The Tendency to Inferior Birds. The breeder may always remember with advantage that just as the bull is half the herd, so is the male among fowls half the flock. A single hen in a breeding flock of poultry influences the progeny from her own eggs alone, whereas the whole of the progeny produced by a pen of breeding hens, which may be six to ten in number, are influenced by the prepotency of the cock. Therefore, however good the hens may be, a faulty or inferior cock may spoil the whole of the progeny, and in the same way, superior blood may improve its entire character, although the tendency in breeding is, under all circumstances, to produce a larger proportion of inferior than of superior birds.



13. SILVER-LACED WYANDOTTE HEN

Reversion to Faulty Ancestors. We must not forget, however, that in the process of crossing there is always a liability to induce reversion to faulty ancestors, and it is for this reason, among others, that the greatest care should be exercised in the selection of breeding stock. In the selection of a cock, for example, the purchaser should ascertain, if possible, how he was bred, and what faults and excellences exist in the strain to which he belongs. The owner of an existing breeding flock may desire to correct certain faults which his birds possess. In order to do this, it is essential that he should obtain from some other yard of poultry a bird, or birds, which, like the family from which they possess these points in unusual excellence. It is obvious that if a purchase be made of specimens which are intended for the improvement of a flock of poultry, but which possess the same faults that exist in the yard to which they are to be introduced, those faults would be intensified. There are points which are practically fixed in all the leading recognised breeds. The rose comb and the white ears of the Hamburgh, for example, are fixed points, but they are sometimes found in otherwise good specimens in a very imperfect form. The comb may be wanting in symmetry; it may be indented on the surface, furnished with a short spike, coarse, fixed either on one side of, or too high above, the head, while the ear may be too small, insufficiently round, tinged with red—a feature which is not uncommon—like the appearance of white in the face of birds of two years old and upwards. No sane man would breed from a Hamburgh with anything but a rose-comb, or from birds with absolutely red ears, even if they could be found, for he would at once impart these characteristics to the chickens he produced.



14. BLACK ORPINGTONS

Let us, however, take an example from a self-coloured bird, one which, in fact, possesses no marking on the plumage, such as the Buff Cochin. This is a bird which for the purposes of exhibition must be large—to the tip a great point—abundantly feathered single comb, and coloured toe, crested with a the whole of the plumage—although the tail is usually very faulty—with a mellow lemon buff tint, the pointed and glossy male feathers of the cock being more brilliant than the remainder of his plumage and than that of the plumage of the hen.

15. LA FLÈCHE HORNED COMB

We may first regard the minor points, which include the comb and the yellow legs, as being fixed, often found alike in good and bad specimens, and yet it is essential that the comb should be symmetrical. Given these characteristics, the breeder will take the precaution to select his breeding stock for their size and form, choosing specimens which are as heavily feathered and as perfectly coloured as possible. If large prices are paid, specimens which are excellent in all these points may be obtained, but there are few persons who can begin in this extravagant way.

Selection of the Fittest. Having, then, secured size and feather, future selection for breeding purposes will be made from the best coloured specimens, and here again it becomes highly essential that the beginner should ascertain precisely what tint is demanded by the fashion of the day, and what to reject. The variations are so great that it will at all times be found difficult to maintain the point of colour, especially as with each moult the hens more or less change the shade of their plumage, for which reason it becomes most difficult to know how to select mature birds. It should be needless to add that under all conditions specimens which are not in robust health, and which do not indeed possess lusty constitutions, should be rejected as useless.

Where birds intended for breeding are selected from the chickens of the year, they should always possess certain leading features, those which are most perfectly fixed. Given this much, the breeder can proceed from year to year with greater confidence towards the fixation of points which are less perfectly fixed. Let us add, however, that although a point may be fixed, it may still be imperfect, as the rose comb in the Hamburgh [10], the single comb in the Cochin, and the pea comb in the Brahma [11]. Size and form are constantly found defective in the very best flocks; hence the necessity in selecting breeding stock of rejecting specimens which are too large, too small, or unsymmetrical. Where birds are carefully mated from year to year the chickens bred will systematically improve, the number of good specimens will increase, and the number of inferior specimens decrease. Thus the breeder is enabled, with time on his side, to make his selections for breeding purposes confident of achieving success.

Varieties Obtained by Crossing. The majority of the existing varieties of fancy poultry have been produced by crossing, and, the points they possess being fixed, they are now recognised as pure in blood. The Plymouth Rock [12], the Wyandotte [13], and the Orpington [14] are cases in point. The first-named was introduced into this country from America over thirty years ago, while the latter are much later productions. Some breeders, not content with the points of certain breeds, have attempted with some success to fix others upon them, and it would not be surprising if an ingenious person were to introduce the two-horned comb [15] of the French variety La Flèche upon some recognised British breed.

As an example of what is possible, and with but little trouble, let us suppose that the Minorca [16], a bird of black plumage with a large white ear

16. BLACK MINORCAS

and a single comb, were selected for the attempt. The Flèche [18], a larger bird, also possesses black plumage and a large white ear. By crossing the two breeds, mating the male of the French with the females of the English breed, for the reason that the prepotency of the male is greater in regard to fancy points like the comb, some success would be achieved in the first season. The pullets—the young females—produced by the union which were the largest in size and which possessed the comb of the Flèche most nearly perfect would be mated with a Flèche cock, and in the second year the breeder might confidently expect to obtain a number of specimens with almost perfectly formed two-horned combs.

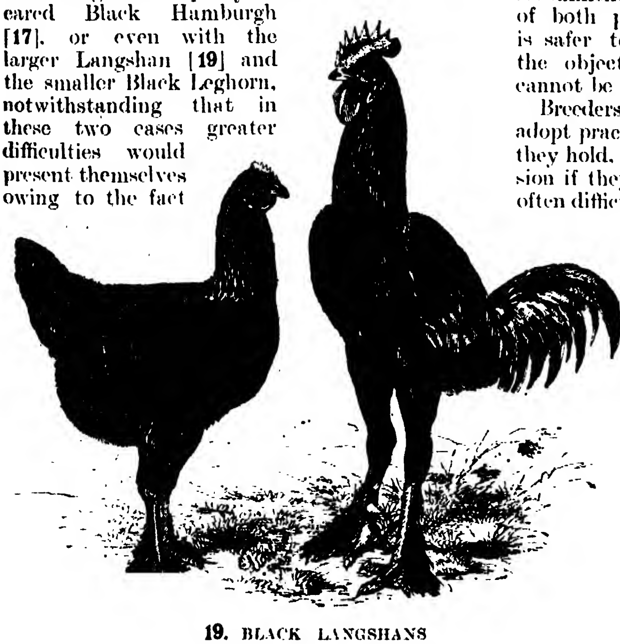
17. BLACK HAMBURGHS

How Size is Secured. Here it may be observed that, owing to the fact that the female exerts the greatest influence upon size, it would be necessary to pay special attention to this feature. Pullets being selected from the cross, and these being bred from hens of the smaller breed, the Minorca would probably have lost size, so that if great size were desired it would become essential to fix it by making further selections from year to year with the object of acquiring it on similar lines to those adopted in the production of a comb. If size were not required, the breeder would probably find it possible in the third year to select both male and female Minorcas with perfectly formed white ears of the characteristic shape and the comb of the Flèche for exhibition purposes. The experiment might be equally made with the white-eared Black Hamburgh [17], or even with the larger Langshan [19] and the smaller Black Leghorn, notwithstanding that in these two cases greater difficulties would present themselves owing to the fact that the Langshan is not a bird with a white ear, and that in every respect but plumage it is dissimilar to the Flèche.

18. LA FLÈCHE HEN

There are many breeders who maintain two strains of birds of one particular variety in order that they may with greater confidence and facility obtain specimens for crossing. But where this is not the case, and where a breeder owning a successful flock sells eggs or birds to others, he may be able, if he keep a careful record of his sales, to select from the yards of one of his customers a specimen for crossing purposes, should he require it, with great advantage to himself. In the breeding of stock of all kinds it has been the practice of some to mate brothers and sisters, although the plan is not one which can be recommend d, for both sexes contain the blood of both parents. If for no other reason, it is safer to mate parent with offspring when the object is to secure qualifications which cannot be obtained in any other way.

Breeders, however, are often compelled to adopt practices which are contrary to the views they hold, and to which they would give expression if they were able, for the reason that it is often difficult, if not impossible, to obtain what is really needed. In the production of Bantams, for instance, it has been necessary to use material of the poorest description because nothing better was obtainable. In such a case in-breeding or cross-breeding would have been much more satisfactory; but a beginning has to be made, and then the mating of parents with offspring follows as a natural result, for essential features can often be fixed in no other way. The reader might also refer to the remarks which we have made on the production of the Silver-pencilled Hamburgh, which is another case in point.



19. BLACK LANGSHANS

Continued

WIRE SHAPE MAKING

Some Essentials in Making the Shape. Handling the Wire. Bonnet Shapes. Taking Measurements. Covering the Shape

By ANTOINETTE MEELBOOM

WIRE shapes are more used than anything else for foundations of hats, toques, and bonnets. They are light and can be made in the most elaborate of shapes, besides being the only suitable foundation for transparent materials. The wire must be nipped without rubbing the thin silk filaments of wire, or the shape will be spoilt [56, 57 and 58]. It should be placed between the nippers and cut sharply and firmly. To smooth or straighten wire it should be rubbed round the knee or the rounded leg of a table.

Edge wire is much the firmest to use for headline and edge. It is not so easily procured retail as the support wire, which, if necessary, may be used for the whole shape. Support wire can be had in any colour and shade for transparent hats and toques, as it is essential that the foundation shape should match the covering and trimmings.

Some points to be remembered in wire shape-making are these: (1) The wire must be lightly handled, firmly fixed, and not twisted; (2) each part of the shape should be well defined by the position of the wires; (3) round wires are placed underneath the support wires, and the two firmly fixed where they cross each other with mounting wire or cotton [59]; (4) the outer edge of either hat, toque, or bonnet shape must be a continuous wire—if joined or broken, the shape is less firm; (5) leave no great spaces between the wires; (6) avoid breaking the thin silk filament of the wire and leave no sharp edges; (7) unnecessary wires only increase the weight of the shape.

Making Hat Shapes. Cut off a piece of wire the length of headline, plus 2 in. for turnings. Join in a circle, overlapping the wire for 2 in., and bind with mounting wire or strong (No. 10) cotton [60A]. Cut off a piece of wire the length of the circumference of brim, plus 2 in. for turnings. Join in a ring and fix as before [60B]. These are the two principal round wires, and are made of the thicker wire, called "edge wire." Where the wires are joined is the *centre-back* of shape. Divide the headline wire in half and quarters for hat and toque shapes [60A].

Cut off a piece of support wire the size of the circumference tip plus 2 in.; join it in a round, and fix as before [59K]. Next cut off the support wires. Take the ring of wire in the left hand, holding the nippers in the right. Measure from the ring and bend at the length of front brim, plus 2 in., with the nippers; bend again at height of sideband, and again at length of tip front to back. Bend downwards the length of back of sideband, and again at the length of back brim, plus 2 in. [62 and 59, A-B]. The 2 in. left at each end is to allow for turning over the headline wire [53] and for nipping over the edge wire [58B].

The side to side wire [59, C-D] and the diagonal wires, right side front to left side back, are done in the same way. Then take the left side front to right side back [59, E-F and G-H].

When the measurements are very varied it is better to nip the support wires to the headline as they are cut off to prevent their becoming mixed. Hold the headline wire with the left hand, place the first bend of the centre support *under* the centre part of the headline. Then, holding the shape near the headline, bend over the support wire and press in place with the nippers. It is quite firm enough if turned round once. Do not rough the silk filament of the wire.

Repeat nipping in the same way for the centre-back, side, and diagonal support wires. Tie all the wires in centre of tip with mounting wire or strong cotton [61]. Place the wire round the circumference of tip with the join at the back *under* the support wire, and tie wherever they cross [59K].

Measure again the exact measurement of brim, front, back, sides, and diagonals, bending up the wire sharply at the measurement. Nip on to the edge wire (in a shape which has both sides alike, the halves and quarters may be marked), nipping over the support wires once right round. Press firmly, and cut off any piece left quite close [58B]. One, two, or more round wires, according to the size of shape, are tied to the support wires wherever they cross [59J].

Dome-shaped crowns are made in the same way, except that there is only one measurement from headline front to back [63].

In the toque shapes, coronets of bonnets, and brims that turn up very much all round, the edge wire is usually smaller on one side to allow the support wires to curve up [64 and 65]. *Coronets* are shaped brims standing out either round the front, side, or back of bonnets [66 and 70]. When a crown is much larger than the headline, the brim is made separately from it; and for extra strength it has two headlines with about 1 in. between them for sideband [68]. The crown should be made separately, and a much larger headline and circumference of tip will be required. Support wire must be used [67].

Some toque shapes with no crowns have wires stretched across from front to back, side to side, and diagonally [69 A & B]. In this case the double headline is also required.

Making a Bonnet. Measurements for bonnet shapes are taken in this order:

Outside edge all round, noting size of front and back, ear to ear.

Centre-front to centre-back, noting depth of coronet in front, and, if a crown, depth of side-band.

Side to side, noting depth of coronet.

Diagonals, noting depth of coronet in front.

Length of crown.

Width and depth of crown.

Round wires.

Coronet wires.

Width between wires round edge.

For the making, cut off a length of edge wire the first measurement, plus 2 in. for turnings. Join it, keeping the join as the centre-back. Mark the centre-front with cotton, and measure half the front measurement on each side. Then bend the remaining measurement, which should be the same as from ear to ear. If possible, the bonnet should be fitted to see that the shape at back meets the hair, and that the front effect is becoming.

Cut off the middle support as previously explained for hats. In the case of a bonnet with coronet, bend the piece measuring the coronet, plus 2 in. for turnings. Proceed with the side and diagonal wires in the same way, nipping them at the back to the edge wire. Tie the supports in the centre. The coronet wire is nipped on last; it is also made of edge wire, bent into curves or points as required. Then tie on the round wire, nipping it at the back to edge wire.

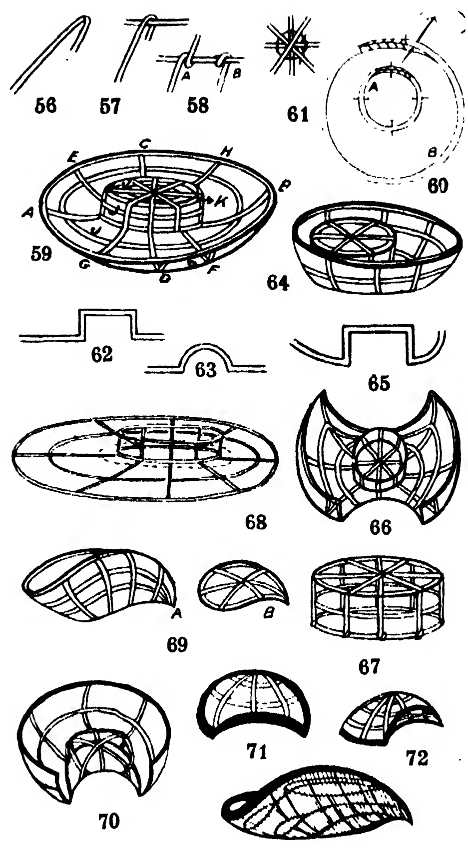
All wire shapes must be covered with tulle, net or chiffon, to take away the hardness of the wire, and to have a foundation on which to sew the trimmings. If the foundation is meant for fur or velvet, leno is better, in which case each part is cut to shape [**66**]. The edge should be bound with mull or sarcenet.

To cover shapes with net or chiffon, take a piece of chiffon, run it along the edge on the outside, "casing" it on slightly. Cut it up at each support wire, pull the chiffon through at the headline, so that it comes outside, and gather it at centre of tip. Fasten it securely and cut off all turnings [**73**].

Some bonnet shapes can be covered with the net in one piece. In this case, place the net in the centre of crown, and smooth over the shape with as small pleats as possible. Bind the edge with a crossway piece of velvet, silk, or mull [**72**].

All bonnets have a velvet fold round the headline, either a crossway piece of velvet, folded double, sewn in before the head lining, or a rouleau, which is sewn in after the bonnet has been lined. This velvet bind is necessary to help the bonnet to set comfortably, to prevent it from slipping, besides keeping the wires from pressing on the head [**71**].

The shape of individual heads, the manner of dressing the hair, and the shapes of bonnets vary so much that it is almost impossible to judge whether a bonnet will be a good fit or no without trying it on the wearer. If it is found that the bonnet does not reach far enough to cover the sides of the head, note where the headline is situated. It is equally possible that the depth or width of the crown itself may require enlarging.



HOW WIRE SHAPES ARE MADE
[Figures **56-73**]

The headline should sit quite firmly on the head, and have no tendency to slip. In making up, care should be taken that no very thick part of the trimming or lining should fill up the head space, and thus make the bonnet too small.

When the trimming requires to be folded in the line of head, as in a close-fitting shape, allowance for this should be made when making the shape.

Wire shapes to be covered and trimmed with net, or such materials as chiffon, lace, or foliage, are covered with double tulle or net. Floral toques have the shape made of green tubing, slipped on green support wire. Tinsel wire is occasionally used as a foundation for lace or chenille. Chenille, fine braids, and cords, very narrow ribbon, narrow strips of tulle or chiffon, are all used over wire shapes, laced closely over and under the support wire. When these are used in a lattice pattern as trimming there is no need first to cover the shape with tulle or net.

Another way of making a wire shape is over a buckram or straw shape, but as it is liable to be larger than the pattern shape, it is only used in a few cases.

Continued

Continued from page 4684

BOYS AND GIRLS AT SCHOOL

The Model School. Exercise and Rest. Care of the Eyes and Teeth. The Importance of Good Food and Warm Clothing

By Dr. A. T. SCHOFIELD

A CHILD of three has a brain six-sevenths of full size, and a child of twelve one nine-tenths of full size, the full weight being reached at fourteen. After this period it is a question in the brain of development rather than of growth. With the body it is not so. It continues to increase in actual size till 18, and the lower limbs till 21, after which growth ceases.

Turning now to school life, we come to matters of great importance with regard to construction. The school itself should be open to the air and sun. The total area on one floor, including school and playground, should have a minimum of five square yards to each child. The basement (if any) should have a concrete floor covered with wood blocks. The school is best if of one or two storeys only.

The School-house. A central hall is good, acting as a reservoir of warm, fresh air for the class-rooms which open into it. There should be no skylights and no point of the room from which some bit of sky cannot be seen; otherwise it is not efficiently lighted.

The light should be on the left of the scholars, and the window space should be one-fifth of the floor area, and never less than one-sixth. The windows should measure 4 ft. 6 in. from the sill to the top. The floor should allow 10 sq. ft. for each child and the height of the room should be 14 ft. Secondary schools should allow 15 sq. ft. for each child. Each seat should be 24 in. to 26 in. wide, and the desks should be at an angle of 40 deg. for reading and 10 deg. with the horizontal for writing. The seats should be such a height that the child's feet can rest flat on the floor, the thighs well supported, the back of the seat pressing below the shoulder blades so that when the arm rests on the desk the shoulders are not pushed up, and the desk should overhang the seat 1 in. or 2 in. There should be four sizes in a large school.

A desk round the wall, 3 ft. 6 in. high, is an advantage. All corridors should be at least 5 ft. wide. The ceilings should be white and the walls tinted. There should be a cloak-room for every 150 scholars, with entrance and exit doors, to hold coats, shoes, umbrellas, hats, etc., and there should be hot air to dry the clothes. The air in schools should be changed ten times an hour: but this is impossible in our climate unless the incoming air be heated. Five hundred children produce 20 lb. of solid carbon in the form of gas every hour by breathing.

Dormitories should never be entered during the day; they should be open, and not cubicles. Five hundred cubic feet should be allowed for each child, and a separate towel, brush and comb provided.

Nearly all schools have too little air space. The Education Act requires only 80 cubic ft. of air space for each child, but the London School Board allows 130. There should be (without heated air) 300 cubic ft. to 500 cubic ft. with a minimum of 250 cubic ft. Closets should be provided at the rate of 15 per cent. for girls, and 10 per cent. for boys, with 5 per cent. urinals. There should be a covered way and a special attendant.

Some Dangers of School Life. With regard to school life some points may be noted. Ninety per cent. of the cases of spinal curvature are produced at this time, due to the rapid growth of the spine and the bad position adopted. Short sight is also common, and a chief factor in both is the carelessness of the teachers. The points are:

(1) Want of proper supervision as to attitude.
(2) Want of proper light to the left of scholars.
(3) Badly constructed and unsuitable desks.
(4) Wrong height of seats according to age.
(5) Slanting desks and curving position of back.
(6) Slanting writing with copy-book to right instead of in front of scholar, and consequent twisting of spine and neck, with the left shoulder raised and the right dropped.

Out of 3,600 children examined, 1,500 were discovered to have defective sight or hearing, and many of these were labelled dull or inattentive simply because they could not see or hear, and they were too shy to say so.

If any child is seen when reading to hold a book less than a foot from its face, or in writing to have the head nearer than 15 in. to the copy-book an oculist should be seen.

A child should be sent home if it has a swollen face, bad sore throat, a sneezing cold, itching skin, ringworm, ophthalmia, or any form of sore eyes, or chorea (St. Vitus Dance).

Over-pressure in School Life. Under 12 years of age there should be no night work after seven; over 12, none after nine. Over pressure is caused in school life by under-feeding, over-study, working during convalescence, night lessons, too little exercise, competitive examination, bad air.

The first is a common cause. Children should eat as much plain food as they can at regular meal times. No parent can judge how much they really require.

After an acute illness children are often very bright and quick, and hence return to school before they are strong. Competitive examinations are a common cause of fatal breakdowns. Ordinary examinations are not injurious; it is the competition that finds out the weak ones.

The signs of over-pressure are loss of sleep, irritable temper, intolerance to light and sound, a twitching of the forehead horizontally, vomiting (when not after meals) and headaches. Should any two of these signs appear, a skilled doctor should at once be consulted.

We have already considered the importance of exercise, although it is a remarkable fact that many of those who excel in gymnastics are found to have overstrained the heart. Drill is valuable for boys and girls, and gives a good figure, while gymnastics, unless properly directed, almost invariably produces rounded shoulders.

Children need regular and sufficient sleep. The hour of retiring to rest must be regular and early, and to ensure refreshing rest the bedroom should be cool and airy, and all active brain work should be stopped at least half an hour before bedtime.

It is good for parents to keep life charts of their children. Every Christmas the weight, height, girth, and physical records of the year should be recorded.

Children's Dress. The clothing of all children should allow the freest motion of every limb and the full action of the lungs. It should be of uniform warmth, and should not leave any vital parts exposed. Unfortunately, this is too often forgotten, and children are dressed in a fashion that their parents would not endure for a moment if applied to themselves.

For all children, flannel next the skin, loose over the body, but well-fitting round ankles and arms, is a needed protection against disease caused by exposure, and money is well invested in good underclothing.

For boys, flannel next the skin, then knickerbockers and a blouse form an admirably healthy dress, which can be followed by a sailor's suit later on. A straw hat or a cap, and a pair of strong, broad boots with low heels complete the outfit.

The less buttoning up about the neck the better the chance of developing a well-formed chest. In cold weather, however, that part must be protected not by mufflers or comforters, but by the clothes, for it cannot be too much insisted on that children require more warmth than adults, not less.

There can be no doubt that a combination flannel undergarment is the most comfortable and healthy arrangement. The legs especially should be protected in this way, and not left bare, or with a single covering of cotton. Over this, with girls, there should be a stout quilted bodice on which the lower garments can be buttoned, and then a plain dress over all. The stockings, of course, are suspended. A sailor costume is a capital one for girls, and very healthy.

The Value of Woollen Clothing. The reason woollen clothing or flannel is so good is because it retains the heat of the body better than any other material, and isolates the body from changes in the surrounding emperature, whether of heat or cold. It also absorbs all superfluous moisture, and is lighter for its warmth than any other material. Fine flannel does not irritate the skin, and children with the tenderest skin can get used to the stockingette flannel now so much used, which, moreover, shrinks far less in washing than the ordinary kind. In our English climate especially, all the protection that flannel can give is needed, and it is far better to spend money in warm clothes than in large fires. The absurd practice of leaving the arms and legs bare in cold weather cannot be too strongly condemned. It has carried off hundreds to early graves, and predisposes children, and especially girls, to early consumption and many varieties of disease. It retards the circulation and digestion, lessens the vital heat, and is therefore a cruel and pernicious practice. Warm, woollen stockings are invaluable, and woollen mittens tend greatly to keep the hands warm. Flannel night-dresses in winter are also very good. Light-coloured clothes are cooler in summer and warmer in winter than dark; dark colours absorb heat from the sun in summer and from the body in winter. Nothing tight should be worn round a girl's body, and, above all, no tight corsets or tight boots or collars or tapes should be used.

Naturally, girls have no marked waists, and to attempt to form one by forcibly compressing the lower ribs is a cruel practice. A well-fitting bodice is all that is needed for the figure. Corsets on growing girls are a great evil in another way. They confine and restrain the growth of all the muscles of the back, and by thus seriously weakening it produce curved spines, round shoulders, and weak backs. No girl can have a graceful figure who has a flat or crooked back. The true secret of a beautiful figure is in a strong spine and well-developed muscles. This gives a poise to the head and an easy carriage of the figure. A capital exercise to produce this is to teach girls to march about carrying a light vessel of water on the head without spilling it.

Care of the Eyes. Children's eyes should be carefully watched, and no reading or sewing by twilight or by a bad light allowed. The proper position for reading is with the back to the light, which should fall full on the page. Near-sightedness is often caused by over study, bad print, and imperfect light. It is seldom found in children before their education begins, but often becomes rapidly developed afterwards. The desks are frequently badly placed for reading, the book being far too low. The result of near-sightedness in children is generally a squint, which speedily tends to become worse, until at last, if neglected, the sight of one eye goes altogether. Any child that is suspected of being short sighted, or who squints, however little, should at once be fitted with suitable glasses.

Another matter of great importance with children is their hearing. Their ears are a constant source of trouble. Beware of neglected colds in the head, as they often lay the foundation of permanent deafness. Omitting to dry the hair after washing it is a common cause of this. Deafness is a frequent result of measles or of scarlatina. It may also arise from a "box" on the ears, or from a constant discharge which has gradually eaten away the inside of the ear.

The Teeth. The care of the teeth is a matter of great importance to children. A child with bad teeth has a bad digestion, a poor appetite, and is in constant pain. From their earliest years children should be taught to brush their teeth with a soft brush, night and morning, with plain water or a little soap. Sweets and hot cakes are great enemies of good teeth; so are nuts, penholders, and string. The Americans, who are very fond of sweet things, have the worst teeth and the best dentists. It is a great mistake to suppose the care of the milk teeth is of no importance. If they are lost early the jaw contracts, and when the permanent teeth appear, they are too crowded, and soon decay in consequence. The first four permanent double teeth are peculiarly liable to decay, and should be examined early so that they may be saved in time.

The hair should be kept short. This is important for cleanliness and for the consequent avoidance of the many troublesome diseases that are prone to affect the children's heads. The hairbrush should be soft, but not too soft, and should be freely used. This is of the greatest importance, not only to keep the hair in good order, but to keep it glossy. Constant brushing draws down the natural oil at the roots into the fibre of the hair, giving it a bright lustre. If the hair is very crisp and harsh, a little of the finest olive oil is the best pomade. Curl papers and curling tongs are both injurious, the latter especially. As a girl grows up, the hair should be kept in a long, loose plait down the back, and not twisted on the head till absolutely necessary.

A word about children's shoes. They should be shoes and not boots, for two reasons. They give full freedom to the growth of the ankle joint instead of restraining it in stiff leather, and they do not stop the circulation, as boots too often do, forming, as it were, garters round the ankle.

Food. Leaving clothes, we now come to a great requirement—good food. This is absolutely essential for proper growth. Few people are aware that a growing boy of ten or twelve requires as much food as a labourer through a long day's work. Growth is not so much a matter of caprice as is generally thought.

The ordinary rule of growth is that a child should increase 2 lb. in weight for every inch in height between three and four feet, and 2½ lb. for every inch between four and five feet. Height is dependent to a large extent on birth and surroundings, and is closely connected with weight. In these respects the more favoured classes have the advantage over the others to an enormous degree. The reasons are that they spring from taller and better developed parents; and they are better fed, less worked, and take more exercise—that is, less indoor work and more game and field sports.

The growing time is a very trying period for health and strength. A child should grow from two to three inches every year; if it is much more or less it is suspicious. All sudden growth should be watched, and lessons relaxed, especially when there is increase in height without increase of weight, which often leads to extreme delicacy.

Children, therefore, to grow well should be well fed. Of course, some are over-fed, but far more are under-fed. Children do not require so much meat in proportion as adults, but an abundance of wholesome farinaceous food. They should not be fed on pastry and rich dishes, but should have plenty of bread, milk, eggs, and cereals (rice, barley, oatmeal, etc.) in every form. As a rule, a child should be allowed to eat as much as he will of plain, nourishing food.

It is as cruel to compel a child always to clear his plate as it is at other times to refuse him more when he wants it. If you think the child is simply greedy, give him dry bread, but give him something.

Again, children often have a hatred and sometimes even a horror of certain articles of food. Fat, under-done meat, eggs, pork, liver, and other things are often hated by children, although a certain amount of fat or butter is desirable. In such cases it is unwise to press them beyond a certain point. Food eaten with aversion or under threats is pretty sure to disagree, and often, as we have seen, a child really knows far better what is suited for him than the parent.

Meals. Children should not be allowed to go too long without food, especially in the middle of the day. It is a mistaken idea that sugar is bad for them; it is, on the contrary, one of the most nourishing articles of diet, and, taken pure with food, is quite wholesome. But it is not so good taken in the form of sweets eaten at all hours of the day, and of more than doubtful composition.

Children should have three good meals a day, and the dinner should be taken early. All raw and starch foods should be very well masticated. Watercress and lettuces are good.

For drink, pure water at dinner; at other meals, plain or flavoured with tea, coffee, cocoa, or milk as wished. One of the most cruel and thoughtless practices is to allow the child to taste malt liquors. They are not only bad for them, but too often form the first stepping-stone to a habit that tends to grow till it is beyond all control.

A child in good health should have a cold bath in the morning in summer, and a tepid one in winter. He should feel warm after it, and should not have it when very hot or very cold, or just after a meal. Cold baths should not be taken at night. Sea bathing is very good when the child comes out of the water warm. Timid children should never be forced to go into the sea.

For washing purposes a warm bath should be taken at night, a flannel rather than a sponge should be used, and plain curd soap. If this is followed by cold sponging the benefit is greatly increased, especially if a tablespoonful of salt has been first dissolved in water, say, a quart. There should be no dawdling; the entire operation should be conducted smartly and briskly, the feet standing on cork or carpet, not on oilcloth.

Continued

SLATE AND TILE WORK

Slates and Tiles. Preparing Roofs. Laying Slates and Tiles. Forming Eaves, Verges, Ridges, Valleys, and Hips. Stone Slates. Shingles

Continued from page 4760

By Professor R. ELSEY SMITH

THE work of the slater consists in covering the framework of a roof with slates to form an incombustible and waterproof covering. The structure of the roof may be formed of wood or iron, or a combination of the two; or it may be formed of iron in combination with concrete; but it must be prepared in some way to receive the slating. In the case of a roof having timber rafters, the cheapest method of preparing the roof is to lay across the rafters at regular intervals sawn laths about 2 in. by 1 in. to which the slates can be nailed [24]. A roof formed in this way may be made perfectly watertight, but cannot be relied upon to keep out snow if accompanied by a driving wind; the snow finds its way between the interstices of the slates and may settle on the ceiling or floor below, thaw, and soak it with water.

Preparing the Roof for Slating. A more satisfactory method of preparing a roof for slating is to cover the rafters with boarding, and to lay on this sheets of inodorous sarking felt or of three-ply Willesden paper, either of which are water and rot proof. The slates may be laid directly on this [25], or better still, sawn laths may be laid as before to receive the slates [26], or where it is desired to keep the space immediately below the roof at a temperature as uniform as possible, 2 in. by 2 in. battens may be nailed above the felt, one directly above the back of each rafter, and the slating laths may be nailed to these [27]. This gives a considerable air space between the slates and boarding, and as air is a bad conductor of heat, this prevents rapid changes of temperature. It also allows any moisture due to the penetration of snow or wet resulting from broken slates to run down the slope of the roof to the eaves.

Where roofs are formed with concrete, wood laths may be nailed to the concrete to receive the slates, or in order to avoid the use of any combustible material, fillets may be formed in the breeze concrete at the necessary intervals. The distance of the laths or fillets from each other will depend on the size of the slates used and the gauge at which they are fixed.

Slaters' Tools. All that are required are instruments for trimming the slates where required for fixing, and for repairing them when necessary. The *cutting iron* [36] is simply a long iron edge on which a slate to be trimmed is placed. The tool is formed with a couple of spikes at the back, so that it can be driven into a wood block or trestle, at a convenient working height. The *zax* [37] is the tool used for trimming the slates; it consists of a blade fixed in a wood handle, with which the slates are trimmed.

In performing this operation the edge of the slate to be treated is rested on the cutting iron and allowed to overhang slightly, and the superfluous material is cut off with a series of quick strokes. At the back of this tool is a projecting spike, with which a line is first drawn across the slate, marking the level of the nail holes, and afterwards the holes are perforated by two smart blows.

Tools for Fixing Slates. In fixing slates the slater is provided with a deep belt with pockets slung round his waist to hold the nails. He has also a hammer [35]; this has a broad head for driving nails, a spike at the further end for holing slates if necessary, and a claw at one side by which nails can be withdrawn. The *ripper* [38] is a tool used in repairing roofs; it consists of a long metal arm, fixed in a wooden handle at one end and provided at the other with a blade crossing it, and provided with a cutting edge at the back, which is also hollowed out on either side of the central arm. The tool is used thus: when a broken slate is to be dealt with, this tool is passed up below the slate and round the nail by which it is fixed and forcibly withdrawn, cutting off the nailhead so that the slate may be entirely removed.

Sizes and Qualities of Slates. Slates are blasted in the quarries, the blocks sawn to convenient sizes, and then split and squared by hand and sorted into various divisions, according to size and quality.

THE CHIEF SIZES OF SLATES IN ORDINARY USE

Name.	Inches.	Name.	Inches.
Imperials ..	30 by 24	Viscountesses .	18 by 10
Empresses ..	26 by 15	Ladies	16 by 10
Princesses ..	24 by 14	Small ladies ..	14 by 8
Duchesses ..	24 by 12	Doubles	13 by 10 or 7
Marchionesses	22 by 11 or 12	Smalls	any smaller size.
Countesses ..	20 by 10		

A good slate should be hard and tough and give a metallic ring when struck, and should not split when trimmed or holed; it should not absorb more than 1 per cent. of its weight in water. Its absorption may be tested by allowing it to stand half immersed in water. If in twelve hours the water has been absorbed so as to reach nearly to the top of the slate it is not a suitable slate to use; in a really good slate the water should not rise to any appreciable extent. Soft slates if breathed upon for a minute or so will give off a strong odour of clay.

Slates vary much in colour, and may be blue, red or purple, and grey. All these colours are to be obtained in Welsh slates, and there are four qualities—*bests*, *seconds*, *thirds*, which are

sold by count of 1,200 per thousand, and *tons*, sold by weight. Bests are the thinnest and lightest and most free from all defects, and make a very neat-looking roof; but the seconds and thirds, which are of the same material, but thicker and less uniform, make a stronger, though heavier and generally less even roof. The ends of slates are sometimes not cut square, but given a rounded or pointed form.

Westmorland slates are green in colour, heavier than Welsh slates, and are not cut to uniform sizes, so that they require to be sorted into sizes before using.

Slates may be laid on a roof of as low a pitch as 22 deg. if large slates are used. Countess slates should not be laid to a flatter pitch than 26½ deg., and small slates to a pitch of 30 deg.

Terms Used by the Slater. When slates are laid in a roof the area of the slate that shows on the completed roof is less than one-half of the total area of the slate; the upper part of the slate is completely covered by the next course of slates, and to some extent by the next course but one. The surface of the slate that remains exposed is termed the *margin* [24], and the depth of the margin is equivalent to the *gauge* [24]; the lower edge of the slate is termed the *tail* [25]; the upper edge of a slate is termed the *head* [25]; the upper surface, when laid, the *back* [26]; the lower surface, when laid, the *bed* [26]. Where the length of the slates used throughout a roof remains uniform, the gauge remains the same; but if the length of the slates varies, as with Westmorland slates, the gauge is varied. The largest slates are used at the eaves, and gradually reduced to the ridge, and in such cases special care is necessary in setting out the laths or battens to which they are nailed.

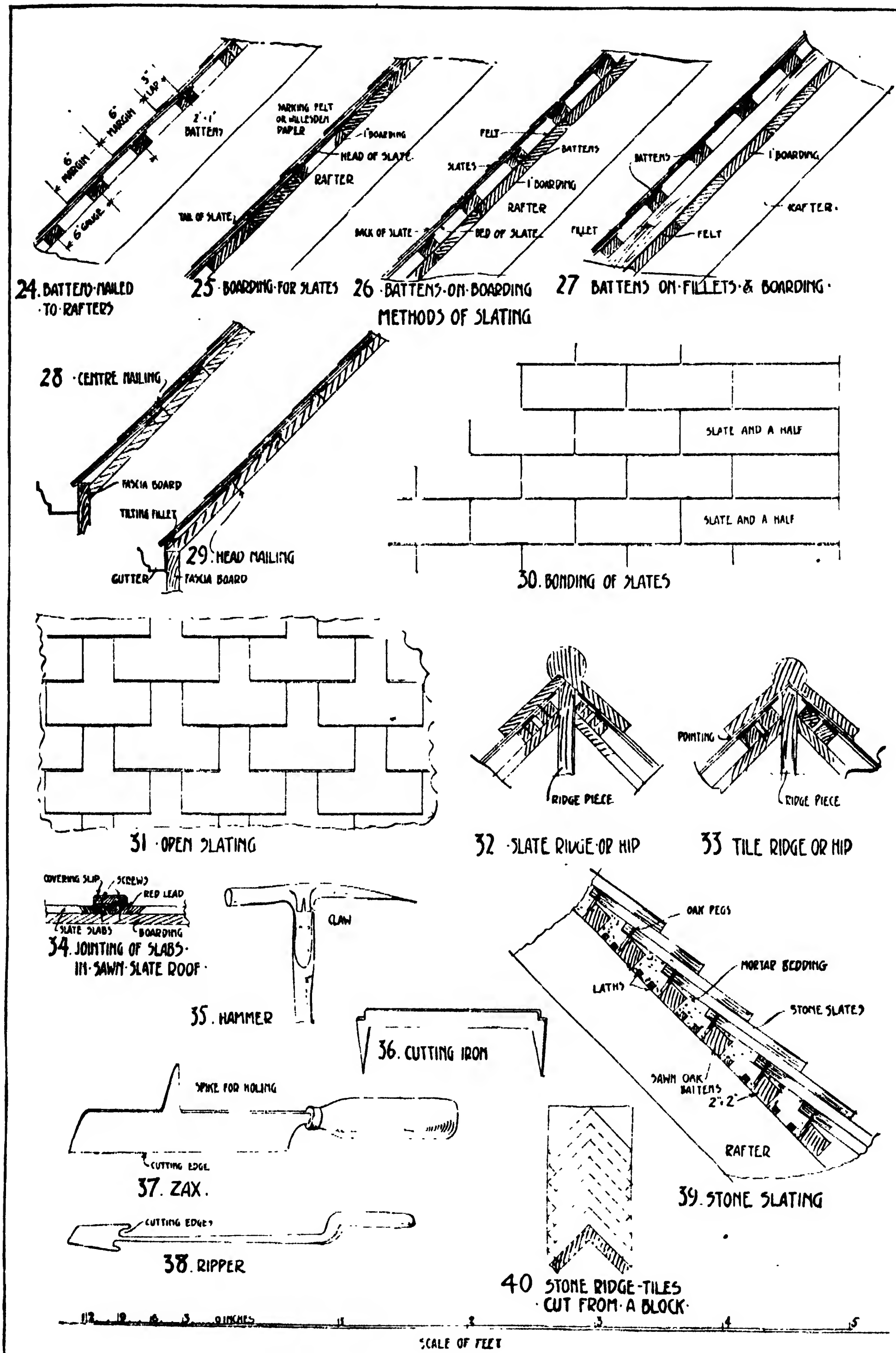
Fixing Slates. There are two systems of fixing slates, depending upon the position in the slate in which the nailing holes are pierced. When *head-nailing* [29] is adopted they are pierced about 1 in. below the head of the slate. The principal advantage claimed for this system is, that the nail hole is protected from the weather by two thicknesses of slate, and in the event of one of these slates being cracked the nail hole is not thereby exposed; its drawbacks are that more slates are required to cover a given area, repairs are less easily effected, and should the wind get under the tail of the slate it may exert a very considerable leverage when the nail is so close to the head. When *centre nailing* [28] is adopted, the holes are perforated only sufficently above the centre of the slates to allow the nail to miss the slates of the course below. This system is considered to give a better hold to the slate, and employs somewhat fewer slates than when they are head nailed; but the nails are protected by only one thickness of slate, and if this happens to crack above the nail hole, water may find its way in.

In both systems the slates are laid so as to have a *lap*, which is a term used to indicate the extent to which the head of one slate is covered or lapped by the tail of the slate in the next course but one above it; the lap is usually not less than 3 in., and when slates are head-nailed the lap is measured from the nail hole, which is at least 1 in. below the head of the slate; but when slates are centre-nailed the lap is measured from the actual head. It will be seen, therefore, that the effective length of the slate is reduced by 1 in. at least when head-nailed, and the gauge which equals the effective length, less the lap, divided by two, is reduced by ½ in., and it is for this reason that, as already stated, more slates are required to cover a given area when head-nailed than when centre-nailed. If there were no lap in slating, water finding its way through the joints between the margins of two adjoining slates might not be received by the slate below it, but miss the head and reach the boarding, or if there were no boarding, drip from the inside. But the length of the lap insures that the head of every slate is several inches above the point at which moisture can come through the joints in the next course of slates.

Bonding of Slates. If a slate roof be examined, it will be found that every course of slates breaks joint with the course immediately below or above it, so that the joint between any pair of slates, laid side by side, coincides with the centre of a slate in the course below [30]. This bonding is regulated at the extreme ends of the roof, but it is not advisable to form the bond with a slate half the width of an ordinary slate, though this is sometimes done, as such a slate would have width for only a single nail, and would be liable to be displaced; but in every alternate course the end slate is half as wide again as an ordinary slate, so that the first joint in such a course comes over the centre of the second slate from the end in the course below.

Slating a Roof. The slater starts from the eaves of a roof and works upwards. The carpenter has provided a tilting fillet, or has kept the top of the front facia above the level of the roof boarding, and provided laths at proper distances to which the slates are to be nailed. The exact distance of the first fillet from the eaves depends upon the size of the slate. In order to provide a double thickness of slate, the bottom course of slates is laid double, and the lower slates in this double course are shorter than the ordinary slates by a length equal to the gauge, so that the tails of the upper and lower slates in the course will coincide, and the joint between the upper and lower rows of slates in the course is broken. The tails extend beyond the facia or tilting fillet about 1 in., so that water running down the roof will drip from the ends generally into a gutter, and the tilting fillet, by raising the lower part of the slate from the boarding, ensures that the tails will fit closely together.

Except the lower slates in the double course, the slates are usually uniform in size till the ridge is reached, where the last row of slates has to be cut to a length about equal to that of the under course in the eaves, and to secure this result the gauge as set out may, if necessary, be varied by a trifling amount throughout the whole slope of the roof to insure that the head of the topmost



DETAILS OF SLATED ROOFS

course but one shall come to within about 1½ in. of the ridge.

Slates are usually laid so that the edges of the slates in each course are in contact ; but considerable economy may be effected by spacing them with a short interval between them. This, which is termed open slating [**31**], does not make so sound a roof, but in positions sheltered from driving rain and for many kinds of outbuildings such a roof may be adequate, but if not laid on boarding, it will be very liable to allow snow to enter.

Nailing Slates. Each slate is fixed with two nails driven through the holes perforated for them into the batten or boarding. The nails are short, with large, flat heads, to cover the perforation in the slate. The best nails are made of copper, and permanently resist oxidation. Nails of malleable iron, galvanised, are also satisfactory, and composition nails, made of an alloy of tin, zinc, and copper, are used, and resist oxidation. Nails made from pure zinc are too soft to drive readily. Lead nails are used when not required to be driven into the wood but to be bent round the batten.

Finishing the Edges of a Roof. The edges of each slope must be treated in a special manner. They may be finished with *verges* where the slates overhang the wall, or may be stopped behind a parapet ; in either case a tilting fillet must be provided by the carpenter to lift the outer edge of the slating and thus prevent any tendency for water to run down the roof and flow over the outer edge. Where verges are used, the slates are usually bedded and pointed in cement, and a wood or cement fillet may be run against the brickwork below the overhanging slates. If the return wall under the verges or parapet be at right angles to that under the eaves, there will be no occasion to do more than provide for bonding the slates, as already described ; but if the angle between them be not a right angle, the slates must be cut with a raking edge, to fit the angle. Slates must also be cut with a raking edge wherever a hip or valley occurs. Slates are not bedded in mortar, but, where laid on battens without boarding under them, are sometimes *torched*—that is, the horizontal joints are pointed in lime and hair from the underside of the roof.

Finishing the Ridge. When the two sides of a roof have been slated to the apex, there will be a joint at the top on each side of the ridge through which water would penetrate ; and there are two or three methods of protecting this. A sawn slate *ridge roll* [**32**] may be used with wings on each side ; the wings and roll may be in three separate pieces, or one of the wings may be in one piece with the roll, and the other then fits under a rebate in the roll. The wings are fixed with copper screws set in white lead to the ridge piece, and the heads are covered by the roll, which is fixed with long brass or copper screws, the heads countersunk and stopped with oil putty or cement : the ridge is jointed in oil putty, and the wings lie on the back of the top row of slates on each side of the ridge. Where the ridge is joined by the hips a special junction piece is employed. Tiles are also largely used for protecting ridges. The most common form is a plain rounded tile [**33**], which simply covers the ridge, and is bedded and pointed in lime and hair mortar ; or specially-formed ridge tiles, formed with a flange to cover the upper slates on each side of the ridge, and usually with a roll or a plain or ornamental cresting, are bedded in the same way. A lead roll is also used, and is described under External Plumbing, together with the means taken to make watertight joints between the sloping surface of slate roofs and the vertical surfaces of walls, chimneys, dormers, etc.

Finishing Hips. Hips may be finished in the same way as ridges, with slate rolls or hip tiles, which resemble ridge tiles, or with a lead roll. The slate roll or hip tiles are bedded and secured as in the case of a ridge, and it is customary to screw to the back of the wood hip rafter at its lower end a piece of wrought iron, of which the lower end is turned up, and often treated ornamentally, as a stop to prevent the lowest tile slipping down ; this is termed a *hip hook* [**42**]. Where the hips cut against the ridge, the joint is best formed with a specially-formed tile to cover the junction. This may be quite plain ; but in many cases at about the point where the intersection occurs the tile is raised considerably above the ridge level, is treated ornamentally, and is termed a *finial*. A similar ornamental finial occurs frequently where the ridge terminates above a gable end, or, where overhanging barge boards are used [see CARPENTRY], the apex is often framed into a wooden finial, against which the ridge tile is stopped.

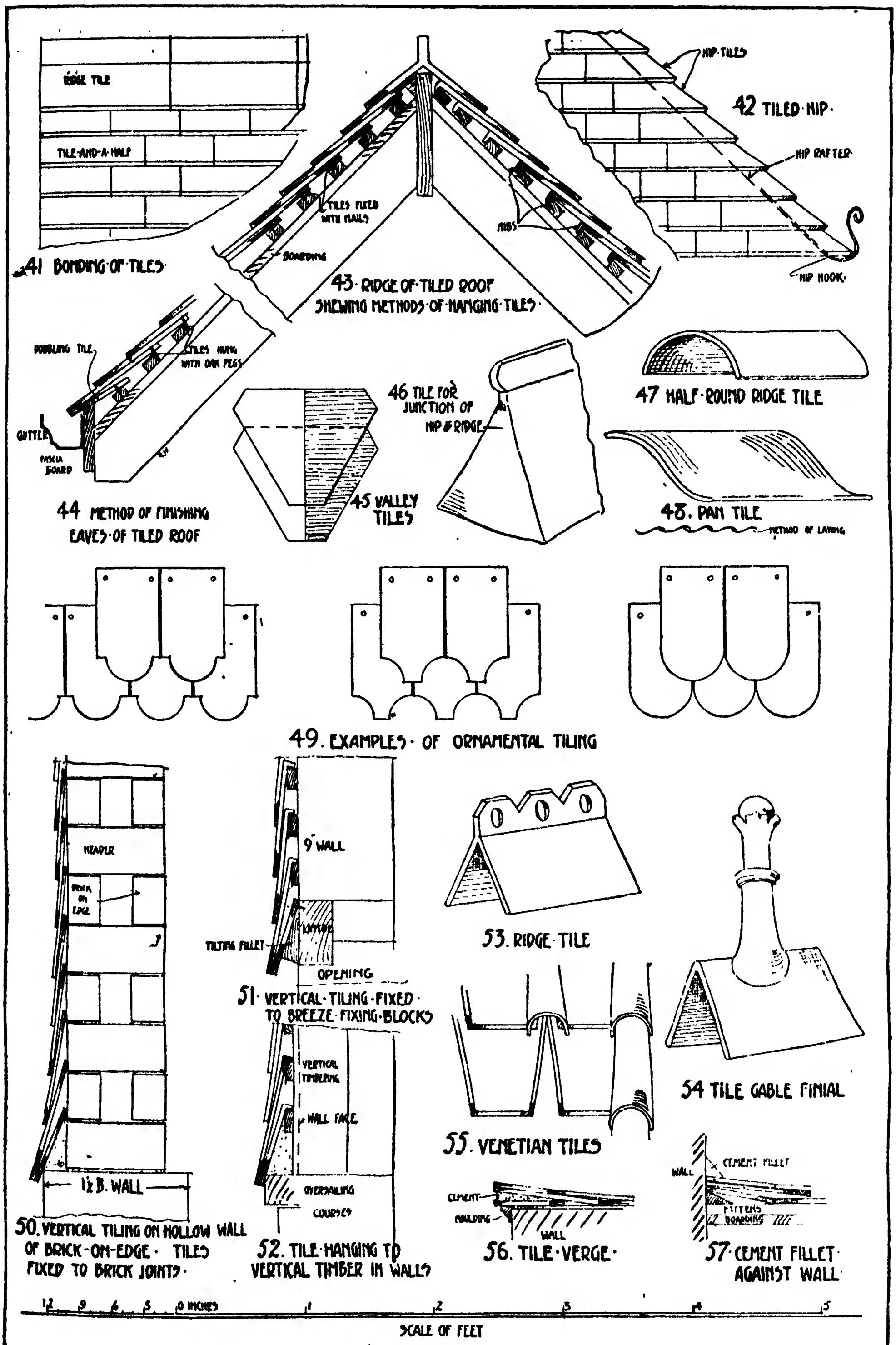
There is one other method of finishing the hip which is not applicable to the ridge. This is done by having the slates closely cut and mitred to the line of the hip and forming a small secret gutter running down the hip, and under the slates. This forms a very neat finish, and, with the concealed gutter, a watertight one [see External Plumbing].

Valleys in slate roofs are formed with lead dressed over a tilting fillet on each side [see External Plumbing], and the slates must be carefully cut to fit the slope.

Glass Slates. Glass slates may be used to admit light to the roof space. They are made the thick, bonded with them, and perforated and screwed to the woodwork. If close boarding be used, it must be cut away under the glass tiles.

The surface of a slate roof may be varied in appearance either by using slates of two different colours in alternate bands or in other geometrical arrangements, or by introducing a proportion of slates the tails of which are cut to a rounded or pointed form.

Repairing Slate Roofs. The method of removing old slates was referred to in describing the ripper. New slates cannot be nailed to the battens, and are secured in position by the use of *tacks*. These are strips of lead or copper, of which the upper end is bent and hooked over the head of the slate in the course below : the new slate is then placed in position, and the



DETAILS OF TILERS' WORK

end of the tack bent up over it to hold it in position. Two tacks should be used for each slate to be fixed.

Sawn Slates. Sawn slate roofs are occasionally used, and are heavy and costly. They may be used either on a timber or iron frame. The slabs may be cut to any convenient size, and are generally about $\frac{3}{4}$ in. thick. The edges of the slabs in each course simply butt one against the other, and are laid in red lead, and afterwards covered by a sawn slate cover bedded over the joint in red lead [**34**]. The slabs and covering slips are fixed by screws, for which holes must be drilled, or, if fixed to iron purlins, bolts are used. The slate must be countersunk to receive the heads of the screws, which are bedded in red lead. The tail of one course of slates laps over the course below about 4 in., and is bedded in red lead. In this form of roof there is no bonding, the joints in every course coming directly over those in the course below, so that the cover strips run up in a straight line from the eaves to the ridge, and each strip laps over the strip below as occurs in the larger slates. A special capping piece is used to protect the ridge.

Vertical Slating. Vertical slating is sometimes employed for the cheeks of dormers and similar situations, and is fixed in the same way as in slopes. Vertical slating is also used, especially in slate districts, for protecting exposed walls from the effects of driving rain. Slates for this purpose may be selected of such a size as to allow the use of a gauge that is a multiple of the height of a course of bricks, so that the slates may be nailed into the brick courses. A lap of $1\frac{1}{2}$ in. will suffice for vertical slating.

Stone Slates. Stone slates, or tiles, are employed in districts where thin, laminated stones are available, and these are sometimes brought to other districts. They are usually about 1 in. thick and upwards, and vary somewhat in size, so that they require to be sorted into sizes. The deeper courses are laid near the eaves, and the gauge is regularly diminished as the ridge is approached. They are usually laid to about $3\frac{1}{2}$ in. lap with a double course at eaves, and cut to ridges and hips, but the valleys are generally formed with shaped stones laid to an easy curve; but lead valleys may be used. They are laid on sawn oak laths, and each stone is fixed with one oak peg. The stones may be *shouldered* in lime and hair. This consists in bedding the heads of the stones only for a short distance down. Another method of fixing is to lath between the battens and to fill in the space with mortar made of stone and lime, and to bed the stones on this mortar [**39**]. The verges and the joints of the stones are pointed, and the hips and ridges may be covered with tiles or with solid sawn stone covers [**40**], at least 8 in wide on each splay, cut in long lengths to suit the pitch of the roof, and bedded and pointed in cement, and with specially-cut junction pieces where the hips and ridge meet, and strong wrought hip iron, as described for slate hips. The flattest pitch that is suitable for a roof covered with stone slates is one of 40°, and the roof timbers and trusses require to be about 50 per cent. stronger than for slates on account of the extra weight of this covering. Stone slating is sometimes used vertically, for cheeks of dormers or for walls, formed with similar stones.

Shingles. Shingles are wood slates split generally from oak, but cedar and larch are also sometimes used; they are usually 6 in. wide, and from 12 to 18 in. in length, and are laid in the same manner as slates, but with a lap of from 4 to 5 in., and are not suitable for a flatter pitch than 45°. They are nailed with copper nails on close boarding. The hips and ridges may be cut out of solid oak in long lengths in the same manner as already described for stone hips and ridges with slopes 6 to 8 in. long, but the hips may also be close cut and mitred, and provided with a secret gutter as described for slate hips, which makes neater work.

Shingling is principally used now for turrets and spires, and in such cases there is, of course, no ridge piece required, but an apex piece will be necessary; and this may be of oak, or of fir covered with lead.

Tiles. Tiles are burnt from suitable earths, but they vary much in quality, colour, and form [see page 644]. Some are light in colour and porous; others, made from very compact clays, are dark in colour, varying from deep red to brown and purple, almost vitrified in burning, and absorbing very little moisture. They are usually slightly cambered, or arched, between the head and tail, and may be perforated with holes for nails, or formed with small projections termed *cogs* or *nibs* on the underside of the head, or they may have both. The size of a tile is usually $10\frac{1}{2}$ by $6\frac{1}{2}$ in. or 11 by 7 in., and the gauge employed is usually $3\frac{1}{2}$ to 4 in. The tails are not always square in form, but may be made ornamental in character. Special sized tiles are made for the under course at eaves, and the top course at the ridge, to avoid cutting; extra wide tiles, known as *tile-and-a-half* [**41**], are made for bonding at ends of slopes, and special tiles are made for both hips [**42**] and valleys [**45**], forming a rounded angle, and of such a form that the tiles bond with those in the adjoining slopes. The forms of these tiles differ according to the pitch of the roof, and must be specially made or selected exactly to suit the pitch employed.

Pantiles [**48**] are usually about 14 by 9 in., and are curved in an ogee curve in their horizontal section; they are provided with cogs.

Cutting and Hanging Tiles. Where the edges of a roof do not finish square, but make an irregular angle, tiles may have to be cut to fit the slope. This is usually done by marking the required line on the tile, and breaking off the superfluous material in small pieces with a pair of iron pincers till the required angle has been obtained, and the operation is finished by rubbing the edge smooth on a piece of stone.

Roofs are prepared for tiling in precisely the same way as for slating; the sawn laths are usually about $1\frac{1}{4}$ by 1 in., and are set out to the required gauge [**43**]. The eaves are laid double as in slate roofs [**44**]. Tiles that have no

nibs are hung to the laths by oak pins driven through the holes provided, or are nailed with nails similar to those used for slating [43].

Tiles that have nibs are hung to the laths by means of them, and may, in addition, be secured by nails; but it is not usual to use more than one nail to each tile, or to nail every course of tiles, as they are largely kept in position by the weight of the courses above; for ordinary tile slopes, if every fourth course is nailed it will amply suffice.

Bedding Tiles. Tiles are not generally bedded in mortar, which, when used, is liable to absorb moisture, but are laid dry, each row resting on the back of the row below, as with slating. Where tiles are fixed without boarding or felt, they are sometimes *torched* like slates—that is, the horizontal joints only are pointed; in other cases the vertical joints are also pointed between the tiling battens. Such pointing will tend to keep any snow from drifting in, but in a well laid roof it is not required to keep out wet, and if the tiles are absorbent it is liable to absorb moisture from them.

Where verges occur tiles are bedded and pointed in cement, and, in the place of the wood fillet used in slating, a tile may be bedded and a cement fillet formed on it in cement; this may be finished with a hollow joint [56]. It is possible to form hips and valleys by cutting and mitreing the edges of the ordinary tiles, and to use lead valleys and rounded ridge tiles as is done with slates; the hips are then bedded in lime and hair mortar, and pointed, but this does not make so good work as using special hip tiles bonded with the ordinary tiling.

Ridges may be formed as described for hips with plain rounded tiles; but, as a rule, a special ridge tile is used—either a roll with two flanges only or with a cresting in addition. There is a great variety in the form of ridge tiles to suit different tastes and styles of work, but they have all two wings, or flanges to cover the ridge, and rest on the topmost row of tiles [53]. Vertical joints between the ridge tiles are unavoidable, and the ridge tiles, or at least the ends of them, are therefore bedded on a layer of cement, and the joints are made in cement. Ridge tiles are usually made in lengths of a foot and upwards. Finials, as already described for slated roofs, are used, but with tiled roofs finials of the same material are usually employed [54].

Ornamental and Vertical Tiling. The appearance of the roof surface may be varied by the introduction of a certain proportion of tiles differing from the ordinary tile either in form or colour. Tiles that have the tails finished in an ornamental form [49] are usually laid in bands of three or four rows and upwards at regular intervals. Tiles of a darker or lighter colour than the ordinary tile may be laid in the same way, or may be introduced so as to form a geometrical design; if this is done, very careful setting out is essential to insure the symmetrical completion of the pattern.

Vertical faces, such as checks of dormers, gable ends, etc., may be tiled in the same way as described for vertical slating; but in such positions the tiles should be nailed, and vertical edges to dormers or similar positions should be solidly bedded and pointed in cement, and the joint between vertical tiling and the slope of the roof is made secure by lead soakers [see PLUMBING].

Vertical tiling to walls is frequently employed in country work as a protection to thin walls. The joints of an ordinary brick wall are not conveniently spaced for hanging tiles, as they give a gauge of 3 in. only; but in localities where a 9 in. wall may be built hollow by using bricks on edge, tiling may suitably be fixed to the joints [50]. This will allow a gauge of 4½ in. A very usual method of hanging tiles is to build in coke breeze fixing-blocks at regular intervals, and secure to them sawn laths 2 in. by 1 in., to which the tiles are hung [51], or the laths may be fixed to vertical timbers built into the walls at intervals of from 14 in. to 18 in. [52]. Vertical tiling may be laid dry, or bedded and pointed in mortar. In the former method the laths are less likely to perish, as better ventilation will be secured; and mortar, as already pointed out, is liable to absorb moisture from porous tiles. Vertical angles are formed with specially made angle tiles, or the ordinary tiles may be cut and mitred, and lead soakers employed. The lower edge of a vertical tiled surface is made to project from the face of the wall either over a brick or stone band, corbelled out at least 2¼ in. [52], or where a tiled surface is stopped over an opening, a wooden tilting fillet is provided [51], the lower courses are bedded in cement. The object of this projection is to throw off any water that runs down the tiles clear of the walls. Where tiling is stopped in a vertical line by the jambs of openings, the outer tiles are bedded and pointed in cement. Where tiling is finished under a wooden window-sill or below the kerb of a skylight, a lead apron is generally closely nailed to the underside of the sill, and dressed down over the tiles.

Repairing Tiled Roofs. Tiled roofs may have broken tiles removed and new ones fixed in position in the manner already described for slate roofs; but where tiles are provided with nibs, and the tiles are not nailed down, it is often possible carefully to lift slightly a few tiles and insert a new one, passing the nibs over the lath, and thus securely hanging it. Some few years ago a slotted tile was manufactured in which the nail hole was provided with a circular slot below it, so that even when nailed the tile could be pushed up so that the slots dropped over the nail heads, and then, by drawing down the tile, it was securely fixed. Such tiles greatly facilitate repairs, but are not in general use.

Pantiles are used only for an inferior class of work; they are not flat, but partly concave and partly convex in cross section, and are provided with nibs, and can be laid to a pitch as flat as 25°, and are not usually nailed. The laths are usually about 1¼ in. by 1 in. Under-boarding or felt is not used. The tiles are laid so that in each course the convex edge of one tile overlaps the concave edge of the next; successive courses do not break joint, and there is no lap in the

ordinary sense, but the tails of one row cover the heads of the course below from 3 in. to 5 in., and the alternate ridges and furrows formed by the tiles run continuously from the eaves to the ridge. The tiles are bedded and pointed in hydraulic lime and hair.

Glass tiles can be obtained to work in with ordinary pantiles, and are perforated and fixed with screws. Ridges are formed with simple convex tiles bedded in cement [47]. Hips may be formed with similar tiles, and valleys with concave tiles; but in roofs of this class hips and valleys are, as far as possible, dispensed with.

Special forms of tiles are manufactured of various kinds, and for these more elaborate precautions are taken against the penetration of wet, and a much larger portion of the bed of each tile is visible in the finished roof, and in some cases almost the whole of the back in thus displayed. Such tiles are more expensive; but, on the other hand, a far smaller number are required to cover a given area. As examples of this class, Venetian tiles may be mentioned [55]. The sides of these tiles are not quite parallel, but converge somewhat, and a rim or edge is formed at both sides, and the edges of adjoining tiles are covered with half-round tiles, also somewhat tapered in their length. This makes an effective-looking roof, and is watertight, but not proof against driving snow. Tiles are also made in diamond and other ornamental forms, with fillets slightly raised on the two upper sides, and a corresponding fillet on the lower surface of the two lower sides.

Pitch of Tile Roofs. The flattest pitch that is considered desirable for a tile roof is 45°, but roofs are sometimes laid as flat as 30°, but should have boarding and felt under them. The timbers of a roof covered with tiles require to be about 30 per cent. stronger than in the case of a roof covered with slates.

Cement Filleting. In both slate and tile roofs where the work is not of a high class, the junctions between the ends of slate roofs and the walls of parapets, chimney stacks, or other brick faces, are often protected by fillets of cement to prevent the penetration of wet at these points [57]. When newly executed, these are usually efficient; but if any movement occurs in the roof, the fillets are apt to break away from the tiles or the wall, and to leave the joint to a considerable extent unprotected.

Roofs of a Temporary Character. Some other forms of roofing may be mentioned, though they are not laid by the slater or tiler. The simplest of these is a covering of tarred felt, which may be laid by the carpenter. The roof to be covered is first boarded, and the felt cut into strips the length of the roof, and laid horizontally, the lower edge lapping over the edge of the boarding and nailed, and the sides turned down over the boarding and nailed. The next strip of felt has the lower edge lapped over the top of the first strip, and is nailed, and in a ridge roof a strip is nailed over the ridge. Such a roof is useful only for temporary work and outbuildings, and has at the best a short life, but this may be extended by tarring the upper side of the felt, and sprinkling it with sand or ashes.

Roofs of Weather Boarding. Another form of temporary roof may be made with weather boarding; this is principally used for vertical surfaces, but may be employed for roofs of sheds and outbuildings having a pitch of at least 27°; about one-quarter pitch and a greater slope than this is desirable. The boards generally have an average thickness of about ¾ in. and are cut with a weathered or feather edge surface—that is, the lower edge is thicker than the upper one, varying, say, from ½ in. to 1 in. in thickness, so that two boards can be sawn out of a plank 1½ in. thick. The under side of the lower edge is sometimes also rebated, so as to fit over the thinner edge of the near board, which insures that the under surfaces lie in a plane. Such boarding is laid on rafters so that the lower edge, whether it is plain or rebated, overlaps the board below it and is fixed with nails. The boards can be obtained in long lengths, and should extend throughout the whole length of the roof, wherever possible, to avoid joints in the surface of the boards, and the boards overhang slightly at the end, forming ridges. The ridge is covered with a ridge piece cut from the solid, as described for roofs, covered with shingles After the roof is covered, it is generally protected with two or three coats of tar. Roofs of this class are used for simple structures and are formed without hips and valleys.

Galvanised Iron and Felt Roofs. Galvanised corrugated iron is made in large sheets, and is sometimes undulating in cross-sections, formed with alternate rounds and hollows, or sometimes with broad flat surfaces, with rounds at intervals. This material may be obtained curved in its length, to suit a rounded roof. It is best laid over boarding and felt. In laying, the sheets are lapped laterally to the extent of at least one corrugation, and when successive rows of sheets occur, the tail of one sheet covers the head of the next for 6 in. The sheets are fixed by galvanised nails or screws, with large heads, and the hole in the sheet is covered by a washer under the nail. The sheets can be cut if required, and zinc flashings may be used when necessary to protect the junction between the roof and vertical surfaces, as in the case of slated roofs. Special galvanised iron ridges are employed for use where a ridge occurs, and these may be made to take the form of a continuous ventilating ridge. Messrs. Braby supply such roofs in special sheets to work in with the ordinary sheets, but including an iron kerb and skylight; these are often useful for lighting the upper parts of structures covered with this material. Ordinary sheets are rolled in lengths of 5 ft. to 8 ft., and in widths of 2 ft. 3 in. and 2 ft. 9 in., with 3 in. or 5 in. corrugations, and in various thicknesses, varying from 16 to 30 in the Birmingham iron gauge. No. 16 is used for good work: 17 to 19 for ordinary work; 20 to 30 for cheaper work.

Continued

THE WORLD'S CEREALS & FRUITS

Tree Products—continued. Berries, Buds, and Barks. Wheat, Maize, Barley, Oats and Rye. Rice and Millets. The Vine and the Olive. Tropical Fruits

Continued from page 4658

By Dr. A. J. HERBERTSON, M.A., and F. D. HERBERTSON, B.A.

Condiments and Spices. Many tropical plants yield condiments and flavourings. The familiar spices—pepper, the berry of one tree; cloves, the flower buds of another; nutmegs, the kernel of another; mace, the lace-like husk in which the nutmeg is enclosed; and cinnamon, the bark of another, are all natives of the East Indies, but have been introduced into other tropical lands. [See FOOD SUPPLY.] Cloves are chiefly exported from Zanzibar and Pemba. The Vanilla orchid, a native of Central America and Mexico, is now cultivated in Bourbon, Mauritius, and other suitable regions.

Cinchona and Camphor. A valuable product of the tropical forest is cinchona, often called Peruvian bark. The cinchona, of which there are many species, is a native of the eastern slopes of the Andes, between 10° N. and 20° S. lat. Near the equator, it grows up to 10,000 ft. above the sea, but in higher latitudes it needs lower elevation. In Madeira, where it is now being grown, it is only found near sea-level. About half a century ago it was introduced into Algiers, Java, and India. It is now grown in Southern India and Ceylon, as well as in Sikkim and British Burma, but not enough is produced to meet the large Indian demand. The bark of the cinchona yields quinine, which is used medicinally as a febrifuge and tonic.

Camphor is obtained by distillation from the chips of the camphor laurel. Formosa supplies nearly all the market. The chief markets are Hong-Kong, London, Hamburg, and New York. Besides its medicinal uses, camphor is used in making celluloid, smokeless explosives, etc.

Bread-fruit Tree and Sago Palm. Two other trees, though not actually wild, require so little cultivation as hardly to be agricultural products. These are the bread-fruit of the Pacific and the sago palm of the East Indies. The sago palm becomes mature at about 15 years, and its pith yields about 600 lb. of sago. A month's work produces twice as much sago as can be used in a year. Once formed, a plantation renews itself without further care, and only a little clearing and planting is required to form a new one. Like the coco-nut palm or the bread-fruit, the sago palm is on the border line of agriculture. The sago of commerce is exported through Singapore. It is rich in starch, and, in addition to its domestic uses, it is used to thicken cacao.

Products of the Agricultural Lands. By far the most important products of the agricultural lands are the cereals, or bread-stuffs. Other important crops are various edible fruits, roots, fibre plants, etc.

The temperate cereals are wheat, maize, barley, oats, rye, and buckwheat.

Wheat. Wheat, the most valuable, has been cultivated for thousands of years. As a result of long cultivation many varieties are in existence. White wheats yield a finer flour, but red wheats are often better suited to poorer soils. American wheats are hard, starchy, and yield little bran. The best varieties of wheat yield as much as 80 per cent. of flour. [See AGRICULTURE.]

Wheat is particularly suited to clay soils and rich, heavy loams. It can stand a fairly hard winter, especially if the ground be protected by snow against deep frosts. Where the winter is not too severe it is planted in autumn, to be more forward in the following season. This is *winter* wheat. *Spring* wheat is sown in spring to ripen in the same autumn. It requires a mean summer temperature of at least 55° F. for three or four months to ripen, and grows best between 25° and 55°, though in Europe it is cultivated as far north as 60° lat. The ideal climatic conditions are cool, wet winters, which make the processes of germination and early growth slow, and warm, sunny, dry summers. These conditions are admirably fulfilled round the Mediterranean.

The Wheat Lands of the World. Wheat is now extensively grown in the temperate zone. Europe produces about half of the world's total crop, but consumes more. The chief wheat lands of Europe are Hungary, Rumania and Russia, all steppe lands. France grows enough wheat to supply her own consumption, but exports a considerable proportion, making up the deficiency by import. In Asia wheat is increasingly grown in the steppes of Siberia, a continuation of those of Russia. In the Punjab and the Northern Dekkan it is an important winter crop. Australian wheat is small in yield, but excellent in quality. In New Zealand the yield is high. In North America immense harvests are grown in the Upper Mississippi basin and in the Red River valley. A very large wheat crop is also raised on the Pacific coast, especially in the Willamette and Californian valleys. This now goes mainly to Eastern Asia. In Argentina wheat is grown within a radius of about 400 miles of the mouth of the Plate River, and the area is increasing with the facilities of transport.

A considerable part of the world's harvests are transported in the form of flour. This is particularly true of the wheat crop of the United States and Hungary. The importing country loses the offal, which is retained abroad for stock feeding.

The world's crop at the beginning of this century exceeded 3,000,000,000 bushels, valued at £556,000,000. It is increasing annually, but consumption keeps pace with it. It has been said that "the world's crop is yearly consumed so nearly to the danger line that very often the visible supply, or the amount known to be in the market, is reduced to a few million bushels." It is a fortunate circumstance that the wide extension of the wheat area makes almost every month harvest time in one or other of the wheat lands of the world.

The yield per acre varies greatly. In Denmark it is as high as 42 bushels, owing to the perfection of the agricultural methods. In England it is 30 bushels, in New Zealand 26, in Hungary 18·5, in Canada 15·5, in the United States and Argentina about 12·3, and in Russia 8·6. There is, therefore, much room for increase in the world's harvest, both in acreage and in yield.

The Wheat Fields of the Future. The competition of the virgin wheat lands, though their yield is much less per acre, is so serious in the aggregate that wheat cultivation no longer pays in this country, nor, indeed, in Eastern Canada and the Eastern United States. The cultivation of wheat in this country has rapidly declined, partly owing to the fall in prices due to increased competition, but partly owing to a series of wet summers during the 'eighties, and of equally disastrous droughts in the 'nineties.

The following table shows the acreage under wheat, the price per quarter of 480 lb., and the import of cereals, raw and manufactured, for the last quarter of the nineteenth century:

Year.	Home supply.		Imports.		
	Acreage.	Price per qr.	Grain.	Meal & flour.	Total.
1875	3,514,000	45/2	51,877,000	6,136,000	58,013,000
1880	3,066,000	44/4	55,262,000	10,558,000	65,820,000
1885	2,553,000	32/10	61,499,000	15,833,000	77,332,000
1890	2,484,000	31/11	60,474,000	15,773,000	76,247,000
1895	1,456,000	23/1	81,750,000	18,368,000	100,118,000
1900	1,901,000	26/11	68,616,000	21,542,000	90,158,000

During this period the maximum price was reached in 1877, when it touched 56s. 9d. per quarter, and the minimum in 1896, when it dropped to 17s. 6d. The following list gives the sources of our wheat supply in percentages:

United States	43·5
Home grown	21·6
Canada	8·4
India	6·8
Argentina	6·5
Russia	6·1
Australia	2·6
Rumania	1·4
Other sources ..	3·1
	100·0

Home grown ..	21·6
Colonial grown ..	18·3
Foreign grown ..	60·1
	100·0

About two-fifths of the total supply is thus grown within the Empire, and rather more than half of this total in these islands. The wheat supply of 1905 presented some exceptional features. India, Russia and Argentina each supplied nearly 25 per cent.; Australia more than 10 per cent., and Canada and the United States each about 6 per cent.

Maize. Maize, known in North America as *Indian corn*, or *corn*, and in South Africa as *mealies*, is grown in regions with warm summer days and nights, and summer rains. In countries with dry summers it requires irrigation. In good summers it ripens in sunny gardens in this country, the green cob, or ear, forming a delicious vegetable. Maize is grown in Hungary, Northern Italy, Turkey, Southern Russia, and Rumania, North and South Africa, Australia, and in Mexico, where it forms the staple food. It is nowhere so extensively grown as in the States of the Central Mississippi Basin, which form the "maize belt." In 1905, 94,000,000 acres produced 2,708,000,000 bushels, the largest single crop in the United States, and four-fifths of the world's maize crop. Most of the United States crop is used in fattening hogs and cattle. This is extremely economical, for meat realises a better price than maize, and the land is enriched by the manure of the stock to which it is fed. The maize imported into this country is chiefly used for feeding horses and cattle. It forms an article of human food as cornflour (finely-ground) and hominy (coarsely ground). Glucose, a substitute for sugar, is prepared largely from maize, about 60,000,000 bushels being thus used annually. Other products are starch and alcohol.

Barley. Barley, the hardiest of cereals, has a wider climatic range than any other, being grown in higher latitudes and at higher elevations. In Norway it grows as far north as 70° N. The best barley is grown in the wheat belt. In this country it does well in the dry eastern counties, and particularly in Scotland. In the United States the best is grown in California. As a foodstuff, barley is being displaced everywhere by wheat, but it is in increasing demand for malting. The world's annual crop is about 1,000,000,000 bushels annually.

Oats. Oats suit a climate where the summers are too moist and cool for wheat. They are grown throughout Ireland, Scotland, Denmark, and Scandinavia, and in the other countries of Europe, except round the Mediterranean, where the summers are too dry. The chief exporting country is Russia. Oatmeal was long the staple cereal food in Scotland, and its consumption as porridge is increasing in this country. Oats are everywhere chiefly used as food for horses. The world's crop is about 4,000,000,000 bushels annually. The weight varies greatly from season to season.

Rye. Rye does well on poor, sandy soils, and is suited admirably to the infertile plain of North Central Europe, where it is the chief cereal crop and breadstuff. It is grown in Russia for home consumption, the greater part of the wheat being exported. Rye bread has a dark colour and a bitter taste. A coarse whisky is distilled from the grain.

Buckwheat. Buckwheat, unlike the preceding, is not a grass; its fruit is rather a nut than a grain. It is also called *sarrasin*, and is said to have been introduced into Europe by the Crusaders, or by the Moors into Spain. It is grown on poor soils for cattle and horses in Russia, North-east Germany, and Britanny. Its acreage in the United States has declined greatly

in the last 35 years. The flowers of buckwheat are attractive to bees, and produce excellent honey.

Rice. The cereals of tropical and sub-tropical lands are rice, millet, and dhurra, or sorghum. The temperate cereals can be grown at suitable elevations, as in the *tierra templada* and the *tierra fria* of the Andes. Rice is the food of perhaps one-third of the human race. It has been cultivated from a remote period in the monsoon lands, where the rains occur at the rice-planting season, and has developed many different varieties. The wild rice, which is found in the marshy lands of Southern Asia and Northern Australia is probably the ancestor of the cultivated plant.

Rice requires a hot summer and complete flooding at certain periods of growth. It is admirably suited to the deltaic plains of the Ganges, Irawadi, Mekong, Menam, Red River, and other great rivers of the monsoon regions of South and South-east Asia. Here its cultivation is least laborious, as no artificial levelling is required, and flooding occurs naturally during the heavy summer monsoon rains. It is, however, too valuable to be confined to such deltaic regions. Over much of the rice area of Southern China artificial levelling and elaborate irrigation is necessary, as in the Chengtu plain of the Min River, described in an earlier series of lessons. Rice is grown in Japan, Southern China and the adjacent islands, the Philippines, Java, Cochin-China, Siam, Burma, India, Ceylon, Egypt, Northern Italy the Spanish province of Valencia, and in the United States round the Gulf of Mexico. From most of the rice lands two crops are obtained in a year. The growth is rapid, especially when the rice fields are under water. At such times the plants grow several inches in twenty-four hours. The rapid growth and prolific yield enable the rice lands to support a denser population than any other. The grain itself is not specially nutritious, being deficient in fats and nitrogen, though rich in starch. It contains little gluten, and does not make good bread. Rice forms the staple food of Japan, the Philippines, the Sunda Isles, Indo-China, and Southern China. It is the largest crop grown in India, but is not the staple food. If mixed with other ingredients, it yields such fermented liquors as the Japanese saki and arrack.

The dense population of the rice lands leaves but a small margin for export. The rice used in this country comes chiefly from India and Burma, or from the United States.

Millets. The millets are indigenous in tropical and sub-tropical countries. Common millet, a native of the West Indies, is a prolific annual 3 ft. or 4 ft. high, yielding a very small but very nutritious grain. It is cultivated extensively in India, where it forms the staple cereal, as it also does among the poorer classes of Northern China, where rice is not grown. Being a quick-growing crop, it is sown frequently for an autumn harvest after the failure of the winter wheats in North China. The so-called giant or Indian millet is the dhurra or sorghum. It grows to 12 ft. or 14 ft. in Northern China and Manchuria, where it is extensively used for distilling spirit. It is also cultivated in India, to a small extent in Southern Europe, and very extensively in Africa, where it is known as Guinea corn and Kaffir corn. In Central Africa much is made into native beer, owing to the difficulty of keeping grain in a tropical climate. Both millet and sorghum are extensively grown in the United States and elsewhere for green fodder.

Edible Fruits. Fruits are an excellent addition to diet, but only in exceptional cases, such as the date in the desert and the banana in Central Africa, do they form staple foods. They are very perishable, and play only a small part in commerce. A common method of preparing them for transport is by drying. A familiar example is the raisin, or dried grape. The canning of fruit has become a very important industry. Tinned pineapples, peaches, apricots, etc., can be bought more cheaply than the fresh fruit. Fruits are also utilised by allowing their juice to ferment. In recent years quick transport and improved methods of storage have stimulated the fruit trade greatly.

Temperate Fruits. The tundra and the high moors of temperate lands produce a considerable variety of small fruits. The cranberry is made into wine in Siberia, and is extensively used in America for sauces, etc. Cranberries are imported into this country from Russia and Northern Europe.

The characteristic temperate fruit is the apple. It is the commonest orchard tree in Southern England and Northern France. The fruit keeps well in transport, and is largely exported from Eastern Canada, the Northern United States and Tasmania, as well as from France and the Continent. The fermented juice yields cider. Apples are preserved by drying in the form of Norfolk biffens and Normandy pippins. The pear has a very similar range, but is less in demand. Cherries, plums, and the temperate stone fruits—plum, apricot, peach, etc.—play little part in the world's commerce in their fresh state, though large quantities are preserved by crystallisation. The Balkan Peninsula produces fine plums, which are extensively dried and exported.

The Vine. The vine grows wild in the Caucasus and Armenia, and was probably originally cultivated in Persia. It requires long, dry summers and very warm autumns, and is particularly suited to the Mediterranean climate, though it is grown for wine considerably further north. An interesting series of experiments made in the 'seventies and 'eighties with outdoor vineyards in England showed that though excellent wine was obtainable in good years, bad seasons resulted in complete failure. For wine, the vine can hardly be grown successfully far north of the Loire in Western Europe, but the northern limit rises with the increasing heat of summer towards the east. Excellent wines are grown on the southern slopes of the hills of Eastern France and the Rhine Highlands, where terracing increases the amount of sunshine received [see Food Supply]. The extreme north limit is reached in Posen, in about the latitude of London.

Further east the summers are shorter and the autumns too cool, and the limit of the vine falls rapidly to the Sea of Azov. The vine is extensively cultivated in Western and Central Asia, but as the use of wine is prohibited in Mohammedan countries, the fruit is preserved by drying. The vine is grown in North Africa, and good wine is made in the French Colony of Algiers. It was introduced in the seventeenth century into Cape Colony, where it is exceptionally productive. In the New World, California exports wine, and the vine is grown as far north as 42° N. in Ontario. In Australia, wine is exported from South Australia, Victoria, and New South Wales.

The Wine-producing Countries. France, however, still leads among the wine-producing countries of Europe, followed by Italy, Spain, Austria-Hungary, Portugal, and Germany. The most esteemed French wines are the clarets grown round and exported through Bordeaux, and the champagnes and burgundies of Eastern France. Italian wines do not keep well, and are little in demand abroad. The most popular are the Tuscan Chianti and the Sicilian Marsala. Sherry, from the district round Cadiz, is the most famous Spanish, and port, grown in the Douro basin and exported through Oporto, the best-known Portuguese wine. Of Hungarian wines, the Tokay of the Theiss is the most esteemed. The Rhine and Moselle wines of Germany are in high repute. Of extra European wines, the oldest favourites are Canary sack and Madeira.

Brandy is the spirit distilled from grape-juice, the best being made in the champagne country. Much so-called brandy is merely potato or other inferior spirit.

Fresh grapes are imported cheaply from Spain and Portugal, packed in cork sawdust. Superior dessert varieties also come from France and the Channel Islands. Even South Africa and Australia contribute in winter. Dried grapes or raisins come from the Mohammedan lands of the Eastern Mediterranean, or from Spain, where the Mohammedan tradition still lingers. Sultanas are a dried, seedless grape grown in Asia Minor and the Ægean Islands. The small, dark currant is practically confined to Greece.

The Olive. The olive-tree is said to attain an age of over 1,000 years. The terraced olive yards of the Sierra Morena in Spain, or of the Tuscan and Campanian coasts of Italy, thus represent one of the most permanent and remunerative investments of human labour. The olive is grown throughout the Mediterranean region, in the Southern Crimea, and round the southern shores of the Black Sea. It has also been introduced into the New World, where it does well in California, Mexico, and Chile, and into those parts of Australia which have a Mediterranean climate.

The fruit is rich in a palatable oil, which is expelled by pressure. This oil is extensively used for table purposes and cooking in the Mediterranean lands, which are too dry for cattle and where butter is an article of luxury. The finest table oils are those of Provence in France, and of Lucca in Tuscany. A second pressure gives a coarser oil, which is used in soap-making.

Oranges and Lemons. Another characteristic group of Mediterranean fruits are the orange, lemon, and citron. The orange-tree lives over a century, and bears several thousand oranges annually. It is grown in all the Mediterranean lands, and in similar climates outside that region. It requires a winter temperature of not less than 40°, and cannot stand frost. The lemon has a very similar distribution. The fresh orange is chiefly imported into this country from the Azores (St. Michael's), Spain, Portugal, Sicily, Malta, the Holy Land, and the West Indies. In the United States oranges are grown in California, Florida, and Louisiana, and large quantities are exported from the West Indies and Brazil. The fruit is frequently preserved in sugar as a dessert sweetmeat. Its peel is candied. From unripe oranges is distilled the liqueur known as curaçoa. Lemons are obtained from Italy, Sicily, and Spain. The lime is largely grown in Montserrat for lime-juice.

Figs and other Temperate Fruits. The fig is cultivated round the Eastern Mediterranean. Dried figs are exported from Smyrna. Other temperate fruits are the almond, walnut, pistachio, pomegranate and mulberry. The latter is important in connection with the silk industry. Its fruit is palatable, but it is grown primarily for its leaves, on which the silkworms are fed. It is widely distributed, from Japan and China, the great silk countries of the East, through Cochin-China, Bengal, and Western Asia into Southern Europe. In the higher parts of Central Asia the dried and pulverised fruit replaces sugar.

Tropical Fruits. Of the immense variety of tropical fruits the most familiar are the pineapple and the banana, though the mango, grape-fruit, etc., may occasionally be bought.

The banana, a native of the East Indies, is now cultivated throughout the tropics, where it largely replaces cereals as an article of diet. The root stock sends up new stems annually. A few months later these are laden with the immense clusters of fruit seen in our markets. The yield per acre is probably greater than of any other food plant, while the labour of cultivation is very slight. Immense quantities are imported into this country from the Canaries, which supply the finest, and from Costa Rica and Jamaica, which send a larger but coarser variety. There is a vast import from the West Indies into the United States. The pineapple, a native of tropical America, has been introduced into the tropical lands of the Old World and Australia. It is largely exported from the West Indies into the United States. The bread-fruit and the coconut palm hardly deserve the name of agricultural plants.

Continued

HAND & MACHINE LACE-MAKING

Hand-made, Point and Pillow Laces. Birth of the Lace Loom. Heathcoat's Lace Machine. Bobbin and Carriage, Comb Bars, Point Bars, and Other Appliances

Continued from page 4765

By W. S. MURPHY

Point Lace. Lace is a fabric formed by interlooping and intertwining threads in the shape of a continuous mesh or figure. The making of lace seems to have been esteemed an elegant occupation for leisured ladies in the early civilised communities, and the art has not lost its domestic and feminine character. Though now of considerable industrial importance, lace-making may be classed with embroidery, crotcheting, needlework, and crewel work. Hand-made lace is divided into two classes—(1) point or needle lace, wrought on one thread and twined into the pattern, and (2) pillow lace, composed of many different threads wrought together to form the fabric. The finest and most valuable of all laces is the "Point d'Alençon," named after the French town most famous for its manufacture. This lace is not a single fabric, but a composition of several, some patterns requiring the assistance of twelve workmen, each making a different part. Brussels point enjoys a high reputation. It also is a composite fabric, being made of ground mesh and figured pattern. Among other famous point laces, the leading varieties are Valenciennes, Caen, Chantilly, and British point. From the nature of the productive method, it is inevitable that the variety of this lace should be very great. Every needle-lace worker gifted with imagination might very well invent a new form of lace.

Invention of Pillow Lace. Point lace is necessarily costly, and accessible only to the very wealthiest class of persons as a purchasable commodity. Lace became industrial and commercial through the invention of pillow lace. A Dutch lady, whose maiden name was Barbara Etterlein, the wife of a master miner in Annaberg named Uttmann, is credited with inventing pillow lace, in 1561.

Method of Making Pillow Lace. First, the pattern is pricked out on parchment or strong paper in pin-holes, and fastened on the pillow or cushion. Providing herself with a number of pairs of lace sticks about four inches long, and each connected with its fellow by a thread which at each end is partly wound round the top of the stick, the worker takes the cushion on her lap. Sticking successive pins upright in the holes, and hanging the threads round each one as soon as it is set up, she begins to intertwist and cross the threads by passing the little sticks over and under each other as they hang down loose on the surface of the cushion. When all the holes have been filled with pins and all the threads have been twisted, and the sprig has been formed, to join the parts of the sprig a stitch is taken up through one of the pinholes with the needle-pin. Through the loop thus made one of the lace sticks is passed, and the thread on it is knotted with one of its fellows. When all the sprigs or parts of the pattern have been formed, they are made up by fixing them on the pillow all together, and effecting the joining by means of threads and lace sticks.

The Hand Method. The lace student should thoroughly understand the hand method. In the "Encyclopædia Française" a writer has given a fine description of the method of making the most elaborate form of pillow lace.

"This is a work in gold, silver, silk, or linen, made upon a cushion by the use of a great number of small bobbins on a design traced upon paper, and two sorts of pins, and which may be looked upon as a composition of gauze, weaving, and embroidery, because there are many points and thick threads introduced, of weaving, for there are parts where there are proper warp and weft, and where the tissue is the same as that of the weaver; of gauze, because patterns are executed upon it, and the threads which might have been considered as being warp and weft are often withdrawn from each other by crossings. Of three things, one is necessary in making lace on the cushion—either to compose or make it from one's own ideas, which supposes imagination, design, taste, knowledge of many "points," faculty of employing them, and even invention of other meshes; or to be able to work out a pattern given on paper; or to copy a lace already made, given for the purpose, which supposes less talent but a perfect knowledge of the art. It is then usually necessary to copy from designs pricked carefully on vellum. The art of the 'piquer' is to discern exactly the points where the pins must be placed in order to keep out the threads in the proper position to form the designed meshes, etc.; to ascertain by careful examination all the points needful to carry out the course of working, composed, as it is, of sometimes intermingled points, and sometimes points succeeding each other. If a mesh be triangular, three pins would be necessary; if quadrangular, four, and one pin must also be placed in the centre to produce the opening required.

"The workwoman, by counting the threads that need to be supplied, knows exactly the number of bobbins—60, 80, 100, 150, or 200—which will be required; and each is sufficiently filled with thread. Placing a large pin on the cushion, and having fastened the threads of as many bobbins as she can attach to this pin so that there shall not be any thread given off unnecessarily, she places and fills a second, third, fourth, and so on in a horizontal line with the first, till all are fixed that are necessary. The pattern is then placed behind the pins. It is not difficult

to learn the mode of making any sort of mesh or point if the threads of which it is found to be composed be each numbered, as 1, 2, 3, 4, 5, 6, 7, 8, 9, and so on, if so many are used in it. Let these numbers be invariably considered as attached to the same threads and bobbins. Think of the first that goes from left to right or right to left as number 1, the second as number 2, and so on. Whenever a bobbin is displaced, consider it a new arrangement of the whole. Have paper at hand, and write the positions down in order to become perfectly acquainted with them—4 and 4, 8 and 8, and so on until they are well arranged in the mind and understood. Thus, a knowledge of the points may be quickly obtained, and the habit of managing, arranging, and finding the bobbins again will be acquired, so that in a week all that is wonderful in the art of lacemaking will disappear—at least, the writer found it so.

"Twisting is accomplished by passing the threads round each other so many times, more or less, as is desired for the mesh, first the two next to one another; then the next two; afterwards taking one of each of these and twisting it with its neighbours before twisting elsewhere. The crown, cross, or knot, is needed to complete the mesh, and its formation closes up, and ties or binds the work.

"Linen work is simply passing these threads from number 1 to number 3, 2 to 1, 4 to 2, and 3 to 4. There is no twist. Then leaving the two bobbins which are most to the left hand, and taking the other two that immediately follow on the left, they pass from left to right, putting 2 on 3, and going on as before. The first movement differs, the rest are the same. Then it was 1 on 3, now it is 2 on 3. Weaving, or cloth work, is always finished by a mesh. The method of making meshes and cloth work being understood, new designs may be easily produced, new 'points' devised and executed, and thus surprising patterns be wrought, filled with previously unknown arrangements of threads."

Centres of Pillow Lace. France occupies the premier position in this industry, Belgium coming next in importance. The chief centres in the former country are Caen, Bayeux, Chantilly, Lille, Arras, Mirecourt, Du Pay, Bailleul, and Alençon. The Belgian pillow lace industry is carried on in Brussels, Antwerp, Malines, Yypres, Bruges, Ghent, Menin, Courtrai, Alost, and the villages round these places. Certain districts in England have been identified with the lace trade, notably Bedfordshire, Buckinghamshire, Nottinghamshire, and Devonshire, each locality having a style of its own, which experts at once recognise. Essentially a home industry, and calling for highly developed skill, pillow lacemaking flourishes best in small rural villages, and sporadic growths have occurred in most counties south of the Wash at various periods. Limerick and Donaghadee, in Ireland, produce laces of special character much admired.

Teaching Pillow Lacemaking. Being a domestic art as well as an industry, many ladies acquire a knowledge of the work for the purpose of making laces for personal use. In London and other large centres, as well as in the rural districts mentioned, private schools exist for the teaching of lacemaking, and several institutions of various kinds include the subject in their curriculum. The Home Arts and Industrial Association, Albert Hall, Kensington, London, S.W., and the Royal School of Needlework, Exhibition Road, South Kensington, are the leading centres of information and instruction on the subject.

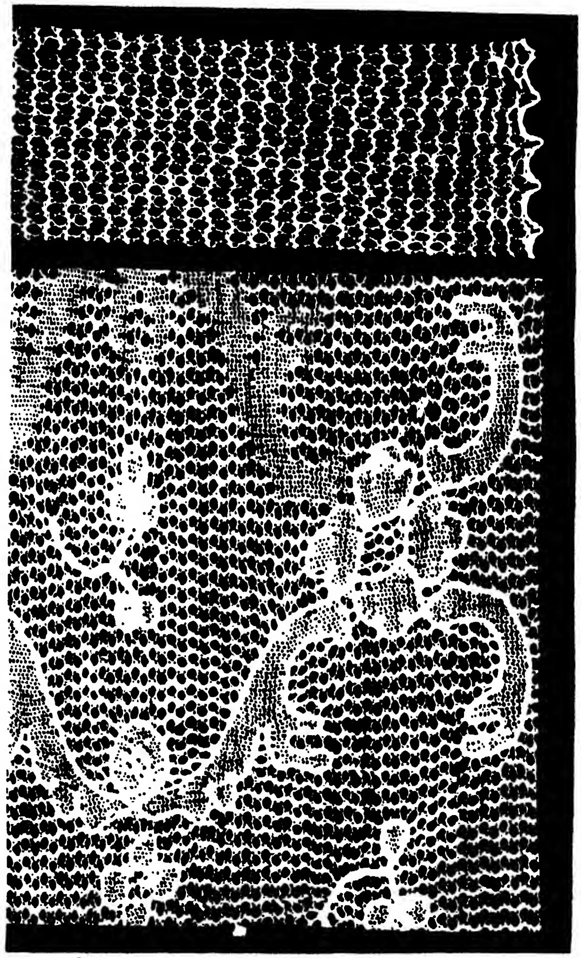
Hand and Machine. Our object being purely the investigation of industrial processes, hand-made lace may appear some little way beyond our province. But the student of lace who does not know something of the hand-made lace industry is ignorant of the basis of the whole trade. Many ingenious mechanics have failed to make practical valuable ideas for the improvement of the lace loom because they had not a grasp of the principles of lacemaking. It need hardly be said that the designer finds in study of hand-made lace the most fruitful source of inspiration.

MACHINE-MADE LACE

Real and Imitation Lace. Machine-made lace was once called *imitation lace*; but the power of the manufacturers has wiped out the distinction. It is ridiculously contrary to fact to say that all hand-made lace is more valuable than any kind of machine-made lace, or that all varieties of the latter are imitations of the former. Many beautiful designs have originated in the designing-room of the lace factory, and much hand-made lace is little better than a waste of good material. The lace manufacturer is kept true to art and utility by the stern discipline of the market; hand-made lace is protected by a prejudice in its favour.

The Birth of the Lace Loom. If one were asked what machine used in the textile industries is the most wonderful, we should unhesitatingly give the palm to the lace loom. Originating from the knitting frame, which is itself a highly ingenious piece of mechanism, the lace loom has been formed into a marvel of mechanical ingenuity. In its early form, the lace loom is simply a hosiery machine used for making lace fabrics. When Strutt added on the ribbing apparatus, and Butterworth and Else contrived the ticklers, the lace loom had actually come into existence. From about the middle of the eighteenth century onwards the adaptation of the hosiery frame to the imitation of lace became the rage among mechanics in Nottinghamshire, Leicestershire, and London. So numerous are the inventors who contributed to the development of the hosiery frame into a lace machine that there is not a historian with any claim to authority but who gives a list of inventors, including some names unmentioned by others. Even Felkin, the historian *par excellence* of hosiery and lace, has omitted some names worthy of mention. Our aim being purely practical, we omit all but the most conspicuous inventors, concentrating attention on the mechanism and the course of its development.

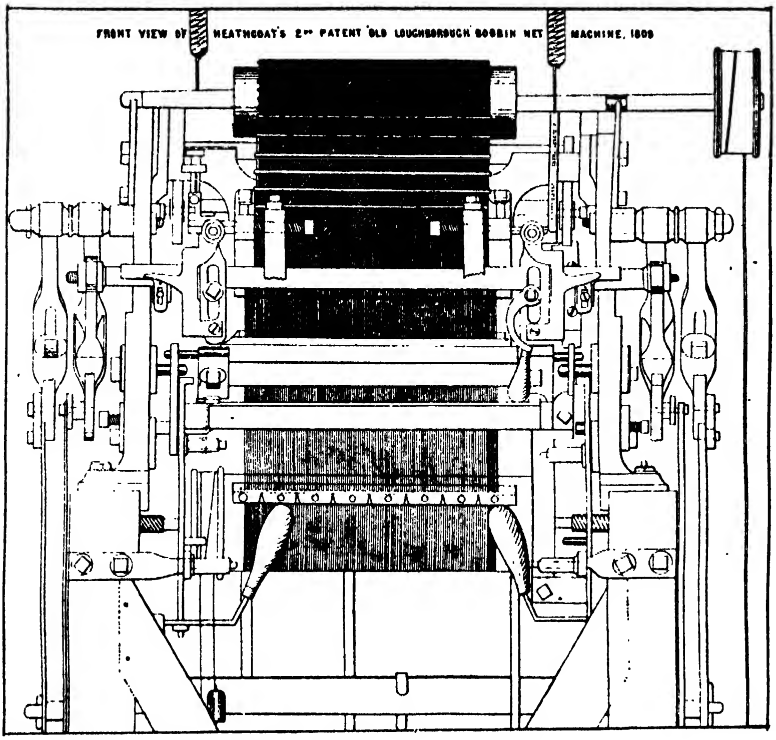
Looping Lace Frame. In 1764 a machine was devised to make frame-looped net; five years later a spoon tickler came into use, by which two loops could be lifted over two needles, and figured net made; in 1768 a method of shifting the threads either from left to right at will was devised, and a kind of cross stitch resembling lace net produced [218]. Thus bit by bit the ingenious experimenters wrought out the problem of producing an imitation of lace by machinery. At last, in 1786, the root idea of the lace loom was conceived by a poor man named Flint. He hit on the method of placing long points on a machine bar which would pass between the needles of the frame and manipulate the threads, forming by two motions the double loop necessary for forming net. A few obvious improvements on this frame brought into existence a practicable point-net frame, and Nottingham, the scene of the labours of Flint and his not too scrupulous supplanters, became from that time the great centre of machine lace manufacture.



218. FIRST LACE MADE ON KNITTING FRAME

Warp Lace Loom. A single thread, no matter how elaborately looped, can hardly produce a substantial fabric. Something more was therefore needed to the full development of the lace frame. This was found in the invention by Crane, of Edmonton, in 1775, of the warp frame. Instead of running a single thread through the whole range of needles, a warp beam was suspended over the frame, and threads from it supplied to each needle. With the implements already devised for the looping frames, the warp frame started on its career with high advantages. Its mobility was greatly increased by the addition of a series of notched wheels, invented by Dawson in 1791, which, through the medium of bars, caused the perpendicular threads to move variously, according to design. This was the forerunner of the now famous Jacquard machine, with which weavers of all the textiles must be more or less familiar. In its later developments, this frame took special forms for special fabrics.

Bobbin-net Lace Loom. After all, the weaver's plan of plaiting warp and weft has something fundamentally right in it, and no perfect texture can be produced except on that plan, however modified and disguised it may be. Looking at the perfect selection of the primitive instruments of industry, one is haunted by the idea that we are the successors of a race of superior beings who inhabited the earth before us, and taught our prehistoric fathers some of the arts of life. Weft is desirable as a means of adding to the texture of a fabric; but lace is not cloth, and a straight weft would not do at all for our purpose. The problem was to combine continuous threads, crossing and intertwining, but without showing straight lines in either warp or weft. It is well understood that if a strong weft is wrought on a weaker warp, the warp will be permanently bent out of the straight line. If, in addition, the weft is tight, and the warp slack, the bend will be all the greater. The deviation thus secured might not be great, but it would be sufficient for a close net fabric. The essential principle of net, however, consists in the fact that the crossing weft itself deviates. A weft thrown across the loom from a shuttle would not answer. Many solutions of the very difficult problem were offered and discarded, till the idea of giving a weft thread to every warp thread was hit upon. This idea came to three men—John Heathcoat, of Loughborough; Robert Brown, of Nottingham; John More, of Croydon. Dispute has arisen often as to the man who had the prior right. We need hardly spend time over that controversy. Both by law and history it has been decided that John Heathcoat was the first inventor of the lace loom as we now know it, and to his invention the student must accordingly turn.



219. HEATHCOAT'S LACE LOOM

Heathcoat's Lace Loom. Invented in 1809, John Heathcoat's loom [219] contains the principle of all the lace looms since used, and careful study of it will enable the student to follow intelligently all the subsequent developments of lace machinery.

Beam Rollers. Two roller beams form the top and bottom extremities of the loom; the lower one is the warp beam, and the upper roller is the cloth beam. The warp threads are thus stretched almost perpendicularly.

Warp Guides. Two sets of upright guides each carry alternate threads of the warp, acting in a manner not unlike the healds of an ordinary cloth loom.

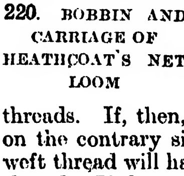
Carriages and Bobbins. Here we come to the first novel feature in the lace loom [220]. The bobbins, *d*, are made of two flat round discs, connected at the centre by a short spindle. Round this spindle the thread is wound, filling up the space between the discs. The carriage, *a*, is a fine piece of brass plate, with horns, *c*, at each side to slip into the catch-bars on which they work within the comb bars. In the improved carriage a round hole with grooves is cut in the centre of the plate, to contain the bobbin, and through the head a very small hole is drilled to let through the thread of the bobbin, or shuttle. A small spring, *b*, is screwed on to the carriage to hold the bobbin in place.

Comb Bars. In the "Old Loughborough," as this loom was named, there were two tiers of bobbins. There were, therefore, two carrying comb-bars, extending the width of the loom. These bars are divided into grooves, or combs [221], extending at right angles to their length. The bars, *k*, are fixed in front and behind the warp threads so that the combs form the segment of a circle. When the carriages containing the bobbins have been fixed in the grooves of the comb bars, the two sets, one on each side of the warp, are kept at equal distances laterally and in the line of the warp threads upon which they are to operate.

Shifting Bars. Hanging in the centre of the circle, the circumference of which is the combs, are long levers, named *shifting* or *conducting* bars. By these the bobbins are made to move like so many clock pendulums oscillating along the grooves. The bobbins are passed half way through the warp threads by the one shifting bar, and are caught by the other bar and carried through to the other side.

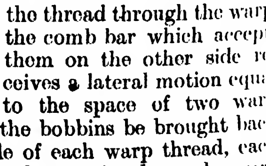
Points Bars. On each side of the warp is a long bar, studded with as many points as there are threads in the warp. These bars are made to move backwards and forwards on pivots, the points passing alternately through the warp. The uses of these points shall be seen in the working of the loom.

Bobbin-net Loom at Work. Having noted the principal parts of the loom, we can now observe the productive process. When the shifting bars have passed the bobbins containing the thread through the warp, the comb bar which accepts them on the other side receives a lateral motion equal to the space of two warp threads. If, then, the bobbins be brought back on the contrary side of each warp thread, each weft thread will have been twisted round a warp thread. If the comb bar in front be now moved laterally till each bobbin stands opposite to the



A. Carriage B Spring
C. Catches D Bobbin

220. BOBBIN AND CARRIAGE OF HEATHCOAT'S NET LOOM

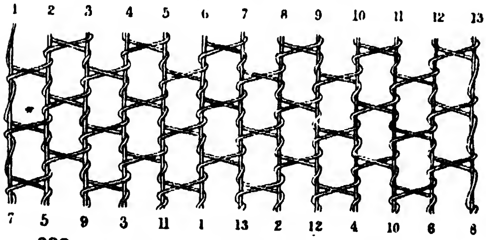


221. SECTION OF COMB BAR

space from which it started first, and the threads be again passed through to the back and brought again to the front of each warp thread, the whole of the threads will have been twice twisted.

Meshing. We have adopted the hypothetical tense in the foregoing because another operation takes place midway in the one described. Before being twisted, one half of the threads of weft must be moved to the right and the other half to the left. This is the work of the point bars. Previous to crossing, every other bobbin is moved so as to form a distinct row, making two rows of the whole, one a little behind the other. The point bars are moved so to enter the first row, and then by a lateral movement slide till the points are opposite to one division further to the left of the second row. The points are now advanced through the second row. As a result, the right side of the threads of the first row is in contact with the left side of each pin, while the left side of the second row of threads is contiguous to the right side of each pin, or point, and the weft threads are crossed. This has prepared them for twisting with the warp threads contiguous to them. The threads thus crossed and twisted are carried up towards the cloth beam, and leave space for further operations. When in the loom, the warp is straight, with the weft twined upon it [222]. After coming off, with the tension of the warp released, a fine mesh [223] is formed.

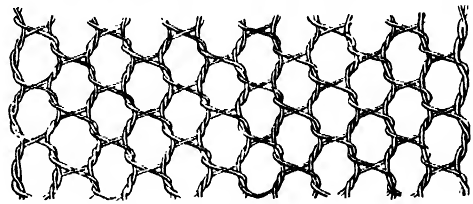
A Clever Adjustment. When each row of meshing has been formed, the weft bobbins and carriages moving to the right will have made the end of that row one carriage and bobbin too many at the right hand, and at the left hand one bobbin and carriage too few. But the same must happen with the row of bobbins



222. BOBBIN-NET AS SEEN IN THE LOOM

and carriages moving to the left. To redress the balance, an ingenious contrivance called a *turnabout* has been invented, which transfers the carriages to the lacking ends, both back and front, restoring the full sets. By this means the course of the weft from end to end of the piece remains unbroken, though each bobbin carriage of the sets changes its place every series of meshes the full width of the machine.

Improvements on Bobbin-net Loom. Heathcoat and many other ingenious mechanics added improvements to the wonderful loom.



223. FINISHED BOBBIN-NET

Most of these improvements, however, are of little practical interest, because consisting in the adaptation of the loom to the production of special fabrics which had their day of fashion and then passed out of use and memory. Others made serious contributions to the efficiency of the loom, the most notable being the "pusher" device of Samuel Clark and James Mart, and the Levers patent. The former as a mere improvement may be briefly noted; but the latter, having become the highest form of lace loom at the present day, must be studied at some length by itself.

Pusher. Always in his mind the lace worker had an ideal loom which would twist, mesh, double, twine, and loop, in all directions without check or limit. For this ideal nearly every loom inventor wrought. In 1812 Messrs. Clark & Mart, of Nottingham, took out a patent for a loom which is thus described: "The carriages containing the bobbins were pushed by long instruments through the warp threads, which bobbin threads were drawn off downwards, and the net thus formed below was carried on a work beam, also in the reversed position. The carriages were held on short combs only by the tension of the bobbin threads. An important difference exists between the double-tier circular machine and the pusher. In the circular (Heathcoat's) pairs of bobbin threads, with their carriages, must necessarily act together. They cannot be parted in operation and effect; whereas in the pusher every bobbin and carriage, being each operated upon by an independent pusher just as wanted, can be obliged to proceed in any direction, or remain at rest. Thus cloth-work can be made more uniform and clear."

Continued

AN ETERNAL LIVING THING

Physics, The Mother of Sciences. Its Conception of the Universe. The World is More Than a Machine. Some Books on Physics

By Dr. C. W. SALEEBY

THERE now remains only sufficient space to sum up the conclusions which we have reached after our long survey of the field of physics, and to make certain comments upon its character. In the first place it is to be noted that there is a whole realm of physics—not of subject matter but of method—to which we have scarcely alluded. This we may call mathematical physics. It would have been out of place here, but that is by no means to deny its cardinal importance. The incessant and inextricable inter-relation of physics and chemistry has again and again been insisted on, both explicitly and by cross-references. In our latter pages we have been introduced, very briefly, to the new science of physical chemistry, which is neither physics nor chemistry, but both, and which is steadily tending to subordinate chemistry to itself and to explain all chemical processes in physical terms.

The Unity of the Sciences. We have also been constantly led to believe that physics is involved in all the other sciences; in studying light, for instance, we saw that we were on the way towards psychology, or, at any rate, physiological psychology. No more than chemistry can this science be divorced from physical conceptions and physical methods. Similarly, in the case of geology it might be shown that these concepts and these methods are all essential. The prime geological problem, for instance, that of the formation and cooling of the earth, is really a physical problem on a great scale.

Similarly, the science of life, whether of animals or plants, is coming every day more clearly to recognise the need of physics. There has been entirely banished from biology the old conception of the vital force. The energies displayed in living matter are included in the "Correlation of the Physical Forces," and the phenomena of living matter display not the smallest infraction of the universal and fundamental physical law of the conservation of energy. In short, if we use the term Natural Science to include all the concrete sciences—physics, chemistry, geology, astronomy and biology—we are forced to the conclusion that before very long, perhaps, all of these will be recognised as physical sciences or as subdivisions of physics—a great name which, as the reader will remember, is derived from the Greek word for Nature.

But the material and the objective are correlated with the non-material and the subjective. Hence the facts of physics have to be recognised even in what used to be called the mental and moral sciences. He will greatly err who ignores physics in his study of mind, as we have already seen. Similarly, it has been shown, and pre-eminently by Herbert Spencer, that physical principles are of value in the study of sociology and even of ethics.

Physics and Philosophy. In a word, physics is, as Bacon said, "the great mother of the sciences," and thus it is pre-eminently the science with which divine philosophy herself has to reckon, or, rather, we should say it is the science with which false philosophies have to reckon, and which, if it be true, renders the most invaluable services to philosophy. Time was when all the phenomena of the world, or, at any rate, all those which were of special interest, were thought to be arbitrary and capricious. The idea of law, as we understand it, was absolutely non-existent, even in the minds of the wisest, 2,500 years ago. It is, indeed, very far from asserting its due dominance over the thinking of all thinking men even to-day. The growth of the belief in law has synchronised with, and depended upon, the growth of our physical knowledge.

One by one, little phenomena and big phenomena have been examined, and found to exhibit constancy. Everyone knows how the phenomena of the heavens were once regarded as dependent upon the arbitrary will of some capricious spirit or spirits; but now your astronomer predicts the return of a comet in a century, and it arrives punctual to the day. Such a prediction is accomplished by the use of purely physical methods, and has established the conception of law in respect of celestial physics. It is only among the most ignorant and superstitious in our own country, or amongst the population of such a benighted country as Spain, where mediæval ecclesiasticism still holds its sway over the human mind, that a comet or an eclipse can cause alarm. The invariable rule is that as knowledge grows the realm of law is recognised to extend. Thus, if we take the branch of physics which to-day is least advanced and least capable of prevision, we shall find, as we might expect, that this is precisely the branch in which the reign of law is least recognised.

The Reign of Law. We have devoted some little part of our course to the study of meteorology, "the Cinderella of the sciences." But everyone knows how far we yet are from effective prediction of the weather. There is no sign of law, at any rate to the "man in the street," and this is best illustrated by the fact that petitions for fine weather or for rain are still sent up in our churches, though no one would dream of praying that, in any particular instance, or for any particular purpose, the law of gravitation should be abolished. Yet the

changes in the weather are due to laws just as invariable as the law of gravitation, which is, indeed, one of them.

Having successfully asserted the dominance of law within its own proper realm, physics has already demonstrated its dominance in astronomy and in chemistry, as physical chemistry is now proving. And the claim of physics is to assert, what every man of science believes, that the sway of law is universal. Every year's advance in science brings further support to this doctrine.

The Unity of the Universe. Physics does even more, because it is ever more positively asserting that the whole objective Universe must be conceived of as a mechanical or dynamical system swayed by the laws of motion, gravitation and the like. When we were discussing the doctrine of energy we saw the tremendous character of the verdicts which physics thus thinks itself capable of pronouncing upon the past history and upon the future of the Universe.

The supreme service of physics to philosophy is, however, the demonstration that the Universe is really a *Uni*verse. This follows in two ways from the creed of physics. In the first place, it follows from the omnipresent sway of physical law. Gravitation is true here and beyond Sirius. The laws of motion were equally true a thousand years ago as to-day. We cannot but believe that the Universe is one if we realise that its modes of action are uniform, all differences of time and space notwithstanding.

Secondly, physics teaches us the unity of the Universe by its grand proposition that all the multiplicity which the Universe presents to us can be resolved into differing but interchangeable aspects of one and the same thing. This, as we have already seen, is a quite modern discovery. Men now living, and notably Lord Kelvin, can remember the days when the doctrine of energy was first formulated. The last few years have amazingly extended this proposition. In still further support of the proposition that the Universe is really one, they have actually enabled physicists to abolish the dualism that had hitherto obtained, of matter on the one hand, and energy on the other.

A Doctrine Swept Away. The doctrine of the conservation of matter, or of mass, has been clean swept away, and we now conceive of mass in terms of the varying velocities of electrons. Matter can no longer be regarded, therefore, as ultimate, and the concept of energy is seen to be more comprehensive than ever.

We cannot say, however, that we have reached any finality, notwithstanding the fact that we have disposed of matter. There remains the ether, our conceptions of which are, as a matter of fact, material, and are merely transferred to it from our conceptions of matter. Nevertheless, physics can fairly claim, and with more verity every day, to have rendered supreme service to philosophy in demonstrating by the scientific, inductive or *a posteriori* method, that which the soul of the philosopher has always inclined to believe, independently of any kind of observation or scientific proof—namely, the unity of all things. The scientist should have no prepossessions in favour of any view. His business is simply to observe and correlate facts; but in so doing he finds that he is inevitably led to a demonstration of that unity which, in the eyes of philosophers, has commonly been regarded as a necessary, intuitive, *a priori*, or self-evident truth.

Physics and Eternity. We are not forgetful that a course on philosophy is awaiting our consideration, and it will be well if from the hard facts of science we can construct a firm foundation for our philosophy. "To the solid ground of Nature trusts the mind which builds for aye" (Wordsworth). The doctrine of the conservation of energy has two aspects, only one of which is represented by its name. It states, firstly, that nothing is destroyed, and secondly, that nothing is created. If this be true now, as the physicist believes, he has no reason to think that it was ever untrue. Now observe the stupendous character of the proposition which we cannot but infer from this doctrine of physics. It is that there was never any "creation" as the mediæval orthodoxy, or the untutored child, conceives of that process. If we go back to the speculations of the great Aristotle, we find that he has no idea of creation—creation out of nothing. The world for him had always existed in some form or other. There never was a beginning. There never was creation out of nothing. But the reader is well aware that certain old views of the history of the world, which no educated person now regards as forming any essential part of the truths of Christianity, were implicitly believed a few centuries ago.

The World is not Merely a Machine. Thus, when after a tremendous struggle the philosophy of Aristotle came to be accepted by the mediæval Church, and was converted into an orthodox form by the greatest of its commentators, St. Thomas Aquinas, one of the greatest men of the thirteenth century, being second only to Roger Bacon, the idea of creation out of nothing, which would have seemed puerile to Aristotle himself, and which, as a matter of fact, is inconceivable, was restored. Modern physics, however, will have none of this, and has gone back to the Aristotelian conception. The doctrine of the conservation of energy directly denies creation out of nothing, which, in any case, is a pseudo-idea that depends for its conception upon the power of words to cheat the mind.

The physical conception of the Universe, then, is that of an eternal machine; but when this conception is corrected by further thinking, and especially by the criticisms of psychology and philosophy, the physicist rather inclines to think of the Universe as a living thing than as an inanimate mechanism; rather as the World Tree than—as Boyle thought—as a mighty clock made and set going by an Almighty clock-maker.

God is Behind the Universe. The thoughtful physicist is well aware that even his best conceptions of the Universe are only

relative and symbolic. He knows that he deals only with appearances or phenomena. He has achieved the most amazing success in observing, correlating, and unifying them, but they remain phenomena still. We must not here anticipate too much what is to be said in a subsequent course, but it is necessary for us to insist once again upon the different and infinitely nobler form which the idea of creation takes in the mind of the modern student of nature. The old idea, as elucidated, for instance, by Aquinas or by Dr. Paley, was that the Supreme Power manufactured the great clock out of nothing, wound it up and set it to run. The clock was one thing and the Maker another. In the eyes of the modern physicist this is no better than a naive materialism, which was quite content to regard our conceptions of a clock and the matter composing it as valid and ultimate. The modern student of natural science believes, in the great words of Goethe, that the Universe is "the living garment of God"; that from eternity to eternity it has been and will be sustained and vivified and informed and recreated every instant by the Unsearchable Power of which it is the manifestation to us.

"A presence that disturbs me with the joy
Of elevated thoughts; a sense sublime
Of something far more deeply interfused,
Whose dwelling is the light of setting suns,
And the round ocean, and the living air,
And the blue sky, and in the mind of man;
A motion and a spirit, that impels
All thinking things, all objects of all thought,
And rolls through all things." *

SOME VALUABLE BOOKS ON MODERN PHYSICS

By far the greatest book that has ever been written on Physics in the English language is the "Natural Philosophy," by Thomson and Tait. Ranking beside this is Tait's "Properties of Matter," while Lord Kelvin's recent publication of his Baltimore lectures may be noted. The "Encyclopædia Britannica" contains important articles (which are not easy reading, however) by both of these authors.

This is not the place for a historical bibliography; we can merely note that in any such list the place of supreme honour will be taken by Newton's "Principia."

Of modern elementary textbooks, two or three may be named, though none of these are modern in the sense of including the developments of the last ten years. Messrs. Macmillan publish an excellent "Elementary Course of Physics," edited by the Rev. J. C. P. Aldous, M.A. Professor Balfour Stewart also left an excellent little book of "Elementary Lessons in Physics," which is popular with students. More recently, Dr. C. G. Knott has covered the same ground with a very lucid and attractive volume.

The elementary textbooks do not concern themselves with what we may call the philosophy of the subject, nor its logic. They do not inquire into the validity of the fundamental conceptions which are presented to the reader. The classical works upon the experimental method and its logic are the "Novum Organum" of Bacon and the "System of Logic" by John Stuart Mill [see the course on LOGIC]. For discussions of the fundamental concepts of physics the reader may be referred to the second volume of Dr. J. T. Merz's magnificent "History of European Thought in the Nineteenth Century," and especially to Chapters VI. and VII., which are historical and critical masterpieces. Still more critical and more fundamental in its attack upon certain of our physical notions is the already celebrated "Science and Hypothesis," by M. H. Poincaré, recently translated and published by the Walter Scott Publishing Company.

For the newer aspects of the subject and for the new ground covered, which belongs indefinitely to physics and to chemistry, the reader may consult several volumes. Popular accounts of the new ground are to be found in "The New Knowledge," by Professor R. K. Duncan (Hodder and Stoughton), and in "The Recent Development of Physical Science," by W. C. D. Whetham, M.A., F.R.S. (John Murray). The Röntgen rays are very fully discussed by Professor J. J. Thomson in the article "Electricity" in the new edition of the "Encyclopædia Britannica." A certain amount of matter on this subject, subsequent to the writing of that article, has been included in our course. For what will undoubtedly prove to be the classical discussion of the new theory of matter the reader must be referred to Professor J. J. Thomson's "Corpuscular Theory of Matter," which, however, has not yet seen the light when these words are being written. Admirable books on radio-activity and its physical problems have been written by two or three English workers at the subject. The best of these is "Radio-Activity," by Professor Ernest Rutherford, of Montreal, Professor Thomson's most distinguished pupil. Another excellent volume, also based upon the distintegration theory, has been published by Mr. Frederick Soddy, now of the University of Glasgow, and was published by "The Electrician." The more chemical aspects of this physico-chemical question will be discussed by Sir William Ramsay in a volume entitled "The Transmutation of Matter," which he is now preparing at the instance of the present writer.

* From "Tintern Abbey," written by Wordsworth at the age of twenty-eight

PHYSICS *concluded; followed by* POWER

continued from page 4784

HARNESS MATERIALS

Leathers and Cloths. Saddlers' Ironmongery. Strap Making and Finishing. Harness Straps and Standard Dimensions

By W. S. MURPHY

HARNESS-MAKERS require a strong, flexible class of leather for belts and straps; pig-skin, real or imitation, for saddles; japanned or enamelled hides for harness collars; and various classes of brown and black leathers suitable for saddle flaps, skirts, and saddles. Selection of these is aided by the leather factors who cater specially for the trade; but the saddler should study carefully the different kinds used, and so be able to make a selection.

Cloths. Girths, bands, and cloths are generally sold in the form required, and we have only to cut them to length. The girths range from 4 in. to 6 in. wide, and are made of wool, cotton, or union. Felts, baizes, canvases, and checks may be bought by the web, and cut to suit; felt is a handy material, making pads, covers, or linings for harness and saddles.

Threads. Saddlers' threads are various, ranging from the flax out of which he makes wax-ends, through common machine-sewing cotton and lint, up to fine silk. In selecting threads, it should be borne in mind that the weakest point in a saddlery outfit must be strong enough to stand much wear and tear.

Miscellaneous Items. Pads may be filled with horsehair, goats' hair, sheeps' wool, or several qualities of flock, ranging in quality from pure raw wool, finely carded, down to mixed cotton and broken rags. Rye and wheat straws are also used for the insides of cart collars. We use different kinds of waxes. The common brown wax is not suitable for light straps and work that must be shown on the harness of carriage horses. Bees-wax, white paraffin wax, and tallow grease are, as will be seen, essential to the work of the saddler and harness-maker. Emery, sandpaper, grease ball, blacking, and polishing pastes cannot be dispensed with in the finishing processes of even cart harness or ploughing gear. Tacks for fastening the work together temporarily, saddle tacks for use and ornament, and nails—*clout* nails they are named—for fastening the ends of belts and girths must also be provided. Last, we must not forget flour paste. This, made of flour and alum boiled together, joins linings, canvas, and inside packings together. Good, thick paste, with a strong gluten in it, comes in handy many a time.

5. CUTTING OUT LEATHER WITH GAUGE KNIFE

Ironmongery. Buckles are required for the ends and joints of straps, varying in size and character according to the proportions of the belts and the class of the harness. The smaller buckles and joint-rings of cart harness are usually of tinned iron, and the large ones are brass. Van, cab, gig, carriage, and riding harness buckles range from cheap tinned-iron to costly nickel-plated, in all the various sizes, or covered with leather, enamel, or celluloid. Unless specially desired by a customer, it is well to stick to plain metal, because none of the coverings devised have given satisfaction. They save polishing paste and elbow grease in the harness-room; but celluloid breaks with a fall, enamel cracks readily, and leather cuts, so that the expense is greater in the end.

Bits. The most expensive item in this department is the bit. Since ever horses were harnessed, the bit has exercised the ingenuity of the harness-maker. Two opposite qualities appear in the bit. On the one hand, the driver or rider must have command, and on the other, the horse should be allowed as much freedom in the mouth as possible. We have a large variety of bits from which to choose, and there are always new ones coming on the market. Among riding bits, the Pelham is most generally used. This bit has a flat bar, long cheeks, and rings for both double and single rein. The hackney bit has a jointed mouthpiece, with rings at each side. The Wilson snaffle driving bit is composed of two rings on a jointed mouth bar, with a pair of loose rings on the bar. On the Liverpool bit the curb cheek is loosely jointed to the solid mouth bar. The Liverpool is coming into vogue as a carriage bit, but old-fashioned people still keep to the large Buxton bit, with the long curb cheeks curved just below the mouthpiece. India-rubber mouth bars are used for shy horses with tender mouths, and there are show bits, stallion bits, and other kinds and styles; but the models described are the most common.

In addition, we require to keep in stock winker plates of many patterns, brass-headed nails, D-rings, and bosses.

Cutting Out. Leather is a costly raw material, and the method of cutting out [5] may make all the difference between profit and loss in

the business. Such a caution need hardly be addressed to cutters in the factory, because the object of the greater part of their training is economy of leather. But the beginner in the retail trade does need a reminder. It seems such a small matter at the moment to pare off a slender

6. CUTTING OUT LEATHER WITH PRESS

strip of leather from a strap cut off liberally from the hide; but put those parings in the scales at the end of a week, and see how many shillings have been dropped. The operation of cutting out by press [6] is economical when quantity is sufficient to cover the cost of the die.

Strap Cutting. In cutting a strap, lay the hide on the bench, the back towards you: mark exactly the breadth with an awl against the straightedge, and then cut with the round knife. Of course, if you use the plough, the straightedge and round knife are not needed. Strap-cutting machines save labour to an even greater extent. Straps of all kinds should be cut the long way of the hide, as the tensile strength of the skin of an animal is greater from head to tail than across the body.

In the cutting-room of the factory, the stuff for each set of harness is cut and put together before any part is sewn; the practice ought to be followed in the smallest of workshops. Cart harness stuff is not cut out in the same order as the stuff for carriage or van harness.

Cart Harness. Leaving out collars and saddles, to which we shall devote separate sections, let us start with the cart harness. All the parts may be cut from hide of the same quality, excepting the winkers, which must be stiffer, and free from oil. For the latter, leather merchants stock special pieces. Horses vary in size, but the following are average proportions:

Head-gear. Winkers, 7 in. by $7\frac{1}{2}$ in.; cheeks, 2 ft. 2 in. by $1\frac{1}{4}$ in.; noseband, 2 ft. by 2 in.; forehead band, 2 ft. by $1\frac{1}{2}$ in.; ear-pieces, 9 in. by $1\frac{1}{2}$ in.; chin-straps, 6 in. by 2 in. and 9 in. by 2 in.; winker straps, 2 ft. by $1\frac{1}{2}$ in.; head-strap, 1 ft. 10 in. by $1\frac{1}{4}$ in.; throat lash, 3 ft. 8 in. by $1\frac{1}{4}$ in.; reins, 5 ft. by $1\frac{1}{4}$ in. and 2 ft. 4 in. by $1\frac{1}{4}$ in.

Body Harness. Crupper, 2 ft. 8 in. by 4 in; crupper ring, $8\frac{1}{2}$ in. by $\frac{7}{8}$ in.; breeching, 7 ft. 4 in. by 4 in.; hind tugs, 1 ft. 8 in.; loin straps, 3 ft. 8 in. by $1\frac{1}{2}$ in.; cart belly-band, 3 ft. 8 in. by 3 in.

The proportions of van and cab harness are quite different from the above:

Bridle. Cheeks, 2 ft. 9 in. by $\frac{3}{4}$ in.; noseband, 2 ft. 8 in. by 1 in.; forehead band, 1 ft. 9 in. by 1 in.; headpiece, 1 ft. 10 in. by $1\frac{1}{2}$ in.; winker strap, 13 in. by 1 in.; throat lash, 2 ft. 3 in. by $\frac{3}{4}$ in.

Body Harness. Bearing rein, 6 ft. by $\frac{3}{4}$ in.; crupper, 2 ft. by $1\frac{1}{2}$ in.; crupper billet, 3 ft. 9 in. by $1\frac{1}{4}$ in.; dock, 1 ft. 3 in.; breeching, 7 ft. 6 in. by $1\frac{3}{4}$ in; hip straps, 4 ft. by 2 in.; breeching straps, 3 ft. 3 in. by $1\frac{1}{4}$ in.; back band, 8 ft.; shaft tugs, 1 ft. $7\frac{3}{4}$ in. by $1\frac{3}{4}$ in.; traces, 4 ft. 9 in. by $1\frac{3}{4}$ in.

Riding harness is lighter, finer, and less elaborate than any kind of draught harness.

Bridle. Cheeks, 9 in. by $\frac{7}{8}$ in.; headstrap, 1 ft. 10 in. by $1\frac{1}{8}$ in.; front strap, 1 ft. $2\frac{1}{4}$ in. by $\frac{3}{4}$ in.; throat lash, 1 ft. 7 in. by $\frac{3}{8}$ in.; reins, 4 ft. by 1 in.

Body Gear. Crupper, 1 ft. 6 in. by 1 in.; billet, 2 ft. 4 in.; crupper dock, 1 ft. long; side straps, 2 ft. 2 in. by $\frac{7}{8}$ in.; short cross straps, about $10\frac{1}{2}$ in.; girth strap, 3 ft. by $1\frac{1}{4}$ in.; chapes and billets.

These measurements are merely approximate, and the minor parts require to be cut according to the size and quality of each job.

Edging, Greasing, Racing, Buckling, and Blacking Straps. It will save us a good deal of repetition if we go through the process common to all straps. Though we speak of nosebands, headpieces, and other things, all are really straps—the whole harness is composed of straps—that is, strips of leather. Examine a harness strap of any kind, and the features of it that distinguish it from plain strips of leather, such as might be used for a razor strop, are indelible straight lines along its length, sharpness of edge, and black colour.

Shaping the Strap. Among the strips of leather gathered for harness stuff we find one intended for a box strap, and with it to practise on, the principle of strap-making can be acquired. Lay the plain piece of leather on the bench, and with the edge-trimmer, shaped like a crooked

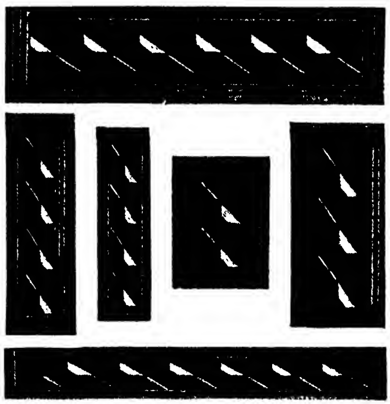
7. HAND-STITCHING HARNESS

tuning-fork, trim the edges all round. Turn the one end over 1 in. or 2 in., according to the size of the whole strap, to form the holder of the buckle; cut a hole near the bend for the buckle tongue; shave the turned-over part thin to the end; at the same time shape the other end by shaving it a little, making a graduated tip with three sides by cutting off triangular pieces from the corners.

Creasing. By these simple acts we have given our strip something like the form of a belt, and to bring it still nearer what is wanted we take up the crease. Turning the screw so that the one creasing leg is almost close to the other, we warm it at the gas, and then, fitting it on to the side of the leather, run it along all sides, making a fine clear line. If another line be desired, screw the crease wider, and draw the line as before. This is an operation constantly repeated in saddlery and harness-making, and has to be carefully done. Of course, if the creasing machine be used, the worker simply holds the strap, and the machine does the rest.

Racing. Racing is practically the same as creasing, with two differences that entitle the operation to a different name and suit it for purposes the crease could not accomplish. A race compass is a divider with a crescent measuring gauge, one leg sharp-pointed, and the other round. With this instrument we can trace lines for sewing or cutting circles, semicircles, turns, and twists. The second difference is that, while the crease only makes a strong, bright mark, the race cuts a shallow channel, and is therefore better for tracing lines for cutting or stitching.

Fixing the Buckle. Put the buckle in the bend of the strap, the tongue passing through the hole, and stitch a tack on both sides to hold it firm. Cut a piece of leather $\frac{3}{4}$ in. broad, one and a-half times longer than the breadth of the strap; skive the ends, strike it square to the breadth of the strap with the hammer on the loop-stick, and insert the ends within the fold that holds the buckle. This is the loop that holds the belt firm after it has been buckled.



8. HARNESS LOOP DIES

Sewing the Strap. We are now ready for sewing [7]. Some belts or straps are sewn with a single thread, and others with a double thread; some are stitched plain, others with a cross stitch, or chain, or locked stitch. The chain stitch with a single thread is most common. Make a thread $2\frac{1}{2}$ yards long, by running five strands that length off the ball, twisting them together under the palm on the knee, waxing, and threading on a needle at each end. Run the pricker along the line where the sewing is to be; thrust the awl at a slant through the first mark of the pricker; insert the needle in the undermost side and draw the thread half way through; equalise the thread above and below by putting the needles together and pulling tight; thrust the awl through the second mark: bring the undermost needle up through; send the needle on the upper side down through: pull tight. A stitch has been made. Sew right on till the buckle has been completely fastened, with the loop held in by the stitches as well.

Holing. The next thing is the punching of the holes in the belt. If this be done by hand, mark the places where the holes have to be with the dividers, and then strike the holes with hand punch and mallet.

Blacken with ink or dye the parts whitened with the cutting, then crease all over again, and polish with a rag.

Making Loops. We have mentioned loops, and though the connection explains the meaning of the term and shows the character of the article, further description is necessary. The loop mentioned above is a fixed loop, put on the neck of the buckle; but there are running loops of various kinds required in harness. A running loop is the movable band which holds in position the loose end of the strap or belt or band after it has passed through the buckle. Some are hard and square, some are ornamented, and others are plain and soft. In hand-made saddlery, looping is a very particular and artistic bit of work. We have loop-stamping machines with special dies [8]. Preparing for the machine, we cut the loop the length of twice the breadth and thickness of the belt, and skive the ends so that the two joined make one thickness of the leather; then the die is fixed and the loop pieces put through the stamping machine.

Having made the leather the proper size and skived it, fold over the piece of hard wood called a looping stick, and hammer nicely down to form the corners. Then draw a pattern with creases, dividers, and compasses, imitative of inlaid wood or in any pattern fancy seems to favour.

Sewing the loop is a ticklish job, if done by hand. Make a channel with the racing compass, and stitch carefully, making sure that the thread catches well on to both sides of the loop. To draw a needle through a space half its length in a square of stiff leather is no easy task; long stitches are therefore excusable, provided they are firm and well taken. A method we think better than using needles is the substitution of the shoemaker's bristles, which, being flexible, allow a sharper curve in a small space. Smooth down the sewing in the channel, and finish off nicely with dye and polish. In this way large running loops for breech-bearers, traces, tugs, and other large belts are made.

Continued

CYCLOPÆDIA OF SHOPKEEPING

SADDLERS. Apprentice and Journeyman Saddlers. Tools for the Working Saddler. Stock and Side Lines, Profits and Prospects

THE trade of a saddler and harness-maker seems to have fallen on evil days. The automobile is ousting the horse from the high roads, and one of the attendant results is the lessened occasion for purchasing saddlery and harness by those who were wont to be the most liberal in their disbursements upon such articles.

It must be recognised by the man or youth who would be a saddler and harness-maker that he is about to adopt a livelihood where the work is hard. In most branches of retail shopkeeping there are respites—often brief, perhaps—from the strain of attention to business, but the saddler can scarcely afford these. His is essentially a working business, and can be properly prosecuted only by the man who has acquired the skill to work at it with his hands. The higher the skill, of course, the greater are the rewards likely to be. But the man who has not learned the trade, and learned it properly, need not think of establishing himself as a saddler. And the retail shopkeeper with many departments will be foolish to attempt to add saddlery as a side line. The risk of failure in such an attempt is almost certain.

The Saddler's Apprentice. As the business is one that can be prosecuted only by a properly trained craftsman and not entered haphazard by a man from an alien trade with some business aptitude, it is proper to consider the question of apprenticeship at greater length than has been our practice in considering other trades. Apprenticeship is general and necessary. The term of service was formerly seven years, but it has become shorter in recent decades, and five years may now be regarded as the most usual term. The period is none too long, as there are a great many practical details to be learned, and the youth who has just completed his apprenticeship is never a thoroughly qualified craftsman. He must gain further experience for at least three years—preferably in a shop other than that in which his apprenticeship was passed—before he can claim thorough competence.

Sometimes a premium is required by the employer, but this is now rare, as the condition of the trade makes it difficult for employers to obtain apprentices even without the premium. Apprentices' wages vary. In many country districts they begin at only 2s. a week, rising to 9s. during the last year ; but in London the wages during the first year are usually 5s. a week. When apprentices live indoors, a custom which is becoming very infrequent, they receive no salary, but a little pocket-money only.

Apprentice Duties. The apprentice has usually to fill the part of message-boy and shop-cleaner as well. His first practical work is to learn to make wax threads of various thicknesses, from three to eight strands of hemp twisted and dressed with black wax for black leather and with beeswax for brown leather sewing. If many hands are kept, this thread-making may occupy most of the time of an apprentice. In some shops the black wax composition—a mixture of pitch, resin, and tallow—is made on the premises. The ingredients are heated together and allowed to cool, afterwards being divided into convenient pieces.

The apprentice's next advance is to the responsibilities of sewing, which demand all his care and attention, as it must be straight and regular. Then it may fall to him to learn the important department of cutting out. Most apprentices, however, are never entrusted with this work, which is most important, as judicious cutting means great economy and unskilful cutting heavy loss by waste, for leather is a very expensive commodity

Journeymen Saddlers. The wages of journeymen saddlers are from 20s. to 40s. per week, and 30s. is about the average. The journeyman saddler frequently has no opportunity to learn the commercial side of the business, his time being spent exclusively, or almost exclusively, at the bench. For this reason the saddler is frequently a bad business man, as he often starts on his own account without any previous business experience whatever. It is worldly wisdom to attain knowledge at the expense of another, and the savings of a man may be dissipated in a short time, whereas, had he obtained some commercial knowledge, say, as the manager of a branch business, or as assistant to attend customers or to buy goods and materials, he might have been qualified to guard and increase his capital.

The Departments. The departments, if we may call them so, of the saddlery and harness business are three—the manufacturing, the selling, and the repairing. The saddler need never be idle. If his attention is not required by a customer he may be doing repair work, and if neither selling nor repairing be possible at the moment he may be making something for stock. There is a distinct advantage in the ability to occupy time thus. If not making a merchant's profit, the saddler can at least earn a workman's wage every day. The repairing of saddlery and harness is an important and lucrative part of the saddler's business, and should be encouraged by every legitimate means, chief among which are the best possible work, its prompt execution, and the never-failing fulfilment of promises.

The necessarily personal character of the business of a saddler is an important factor, and although customers can procure their requirements at some of the large stores, most of them patronise the "single-business man." It is most

important that collars and saddles should fit their wearers exactly, should conform to Nature, and not conflict with it, so that the ability to fit well is the first essential for a successful saddler.

Capital. Many saddlers start in a small way of business with a capital of not more than £100. With only this amount at disposal the selling stock must be small, as the greater part of the sum must be spent in working material, which is expensive. To open a medium-class business, the sum of at least £250 is required, and we may take this as a typical case for consideration. With such a sum financial pressure will be felt in intensity as the volume of business is great, because credit prevails to such a large extent, and the saddler can seldom receive payments as promptly as he has to make them.

The premises required must be fairly commodious, but need not be in the principal thoroughfares if rents there are too high, as the orders are usually given by coachmen and grooms, and not by the masters. The shop fittings are not elaborate or expensive—a strong, solid bench at which to work, a counter upon which to cut out and from which to serve customers, a few glass wall-cases for the better-class stock, such as bits, spurs, stirrup-irons, whips, and brushes, plenty of hooks and brackets from which to suspend harness, a dummy horse (we saw a good second-hand one of full size for which £6 10s. was asked a few days ago), a rail on which to show saddles, a good supply of wooden shelves placed at different heights, and a small desk. All these, with the necessary working tools, would absorb, say, £50 of the capital. The rest of the money, or the greater portion of it, would be spent upon the raw materials of the craft and upon stock, such as whips, horse-rugs, sponges, low-priced collars, and saddles, and proprietary articles, such as embrocation and harness composition, etc.

Tools. The tools required by the working saddler consist of the following:

An assortment of needles for harness and collar work, two paring knives, a round knife for thinning the edges of leather to give a rounded appearance to lined straps, breeching straps, etc. Head knife for cutting circular shapes or holes in leather, plough-cutting gauge for cutting straps and belting. Spokeshave to trim and finish the edges of traces, etc. Three edge-trimmers of various sizes, two pairs of sharp and strong scissors for cutting linings, basil and thin leathers. Washer cutter, punches in half a dozen different sizes, both round and oval (ovals are better, as they make holes in straps large enough without impairing the strength). Buckle tongue punches, a girth-chape punch, a brace end punch, a hand punch with various sizes of nipples to screw in (this is handy to make holes in harness while being worn), mallet, 3 lb. block of lead, scalloping irons (Vandyke, round, straight, and half-moon), rosette punches, two hammers (one fairly light), pricking iron, wheel prickers, two screw races, single creases, three checkers, beveller, a flat steel rule, a pair of compasses with screw and regulator, a pair of race compasses, a few awl blades and hafts, bent awls, sewing awls, a hand and palm iron, a thimble, a pair of clamps to hold the work while being stitched, nail claw, cutting pliers, pincers, nippers, iron collar rod, a vice, a small wrench, a hardwood stick about 30 in. long having a V-shaped point for filling the body of collars with straw, a steel seal iron, loop sticks, a boxwood rubber, a straining fork, files and rasps, and a pair of hand wool carders.

The whole of these tools can be bought for about £6. They should be arranged along a board fixed at the back edge of the working bench, loops of leather of various sizes being fixed to take the different articles. "A place for everything and everything in its place" is a good rule for the saddler who would be expeditious and economical at his work.

Materials. The materials to be used for the making of saddlery and harness which the beginner must buy comprise the following:

Threads of hemp, black wax, beeswax, etc., linen and silk threads, nails, cut tacks of various sizes clout nails, round-headed and japanned nails, nails with nickel, silver, or brass heads, rivets of all kinds, dyes, blackings, varnish, tallow, soft soap, harness jet, and compositions.

Flocks for stuffing collars, etc., horsehair, doe's hair, felt for pads, leather of all kinds, both brown and black; webs of various widths and colours; spurs; stirrup-irons; harness furniture in brass, nickel, and plated silver; face pieces and name plates; trees or foundations for cart, gig, and riding saddles; buckles in brass and plated in many sizes; Ds., Ss., etc.; hip chains, bits, snaffles, curbs, hames in brass and plated.

Collar check for lining cart collars, and saddles; blue serge for lining gig saddles, etc.; white serge for lining riding saddles; kersey for making horse covers, bandage serge, bindings of all descriptions, both coloured and white.

The Stock. Saddlers should manufacture most of their stock of harness and saddlery. Factory-made goods are somewhat lower in price than shop-made goods, but the process of rapid manufacture pursued in the factories does not make for the best quality, and the saddler is wise in his own interests who discourages the factory articles for his own productions. We may cite a few articles in saddlery and harness which will be in frequent demand with the usual prices charged. We confine ourselves to good medium-class articles.

	£	s.	d.
Complete set of gig harness (hand sewn), brass furniture, brass-covered hames, patent leather collar and saddle, bridle with Buxton or Liverpool bit, chain front	6	6	0
The same with plated furniture .. extra	2	2	0
Separately, the items work out thus:			
Patent leather collar		14	0
Brass hames		10	0
Pair traces		18	0
Bridle and bit	1	0	0
Saddle and breeching	2	15	0
Reins		10	0
Brown leather sets are charged extra in some cases.			
Rush collars		5	0
Head collars .. .. from		5	0
Kersey rugs	1	10	0
Complete suit of kersey clothin ..	3	5	0
Hemp rugs for stable		12	0
HUNTING SETS.			
Gentleman's riding saddle, with girths, stirrups, and stirrup-leathers, from £2 10s. to	6	6	0
Ladies' ditto .. from £5 5s. to	10	0	0
Double-rein bridle .. .. .. from	1	10	0
Hunting breastplate .. .. ,,		12	0
Martingale		5	0
CART HARNESS.			
Per Set .. .. about	5	10	0
Singly, the prices are about:			
Collar		16	0
Hames		7	6
Cart saddle and breeching .. .	2	10	0

	£	s.	d.
Bridle with bit		14	0
Belly band		10	6
Reins		12	6
HARNESS FOR LEADER HORSE about	4	0	0
Bridle		14	0
Collar		16	0
Hames		7	6
Hip strap and crupper		15	0
Gear belly-band		5	0
Backband		12	0
Gear chains		8	0
Set stick		2	6

Leather. The fluctuations in the leather market give opportunity to the cautious speculator, apart from the mere manufacture of his saddlery and harness. Naturally, a rise in the price of the raw material demands an increased price for the manufactured article, although many tradesmen are slow to grasp the fact. Within the last year leather has advanced from 10 to 15 per cent. The man who was prescient enough to buy a year's supply ahead, and also to advance his prices, has at least his net annual profit.

In purchasing leather, the buyer must trust greatly to the honour of the seller, and having found a house that treats him well, be loth to change his market by any specious inducements.

The price of leather varies very much. For instance, strained leather basil (sheepskins) has recently gone up from 1s. 3d. to 2s. 6d. per lb. At present good harness backs rule from 1s. 9d. to 2s. 6d. per lb., and good harness bellies about 1s. 3d. per lb. White leather, which is much used for sewing and for repairing cart collars, costs about 1s. per lb.; hogskins from 13s. to 20s. each, and patent leather or japanned hide from 3s. to 3s. 11d. per lb.

Prospects of the Trade. The effect of the motor-car upon the saddlery trade is appreciated only by those who know the trade well. The extensive services of motor omnibuses is an additional cause of alarm, already acute from the extensive following of the motor fashion by private owners. The collar trade especially has been seriously affected. Motors do not, and probably never will, affect the hunting trade, to which, therefore, the efforts of members of the trade should be directed. Hunting saddles should be of the very best quality, as they have very hard wear. At present, saddles with plain flaps are preferred, but for poor riders saddle-flaps with knee rolls should be recommended, as they afford a much firmer grip. Saddlecloth and numnahs are not used in the hunting field, and it may be mentioned incidentally that saddle linings must not be patched, as, if they are, they are likely to cause sores.

If military contracts can be secured, it is often a good thing. The profits are small, but the orders are large and the money certain.

Sundries. The list of saddlers' sundries is numerous. It comprises:

Brushes of all sorts, body brushes, whisk dandy brushes, whalebone dandy brushes, bass ditto, water brushes, spoke brushes (with and without handles), mane brushes, harness and boot brushes, breeches brushes, compo and carriage cushion brushes, cloth brushes, carriage washing brushes, oil and hoof brushes, dog and stable brushes; horse toppings, gig lamps, sponges, chamois leathers, creams, revivers, burnishers, and glove brushes; nose bags, halters and halter reins, stable fittings; horse clippers, singeing lamps, scrapers, curry combs, mane combs, stable baskets, buckets, coaching baskets, etc.; corn servers and measures, whips, hunting crops, whip sockets, thongs, whipcord, etc.; body-belts, girths, singlets, rugs, horse nets, bandages and rubbers, horse boots, kneecaps, body rollers, horses' bonnets, etc. Blackings, dubbings, polishes, cleaning pastes, embrocation oils, soaps, etc. Unfortunately the last-mentioned articles are usually sold at cut prices by the stores and grocers. The saddler must protect himself by buying in the best market and making up his own blackings, dyes, etc., and by pushing their sale.

Helps to Business. There are a few public functions which help the saddlery business, and advantage should be taken of them and trade pushed among the horse owners who patronise them. They include—

The Coaching Club Meet in Hyde Park. The Four-in-hand Club Meet in Hyde Park. The Whit Monday parade of Cart Horses in Regent's Park. The May Day parades of horses in the streets, which do much to promote the men's pride in their horses.

Side Lines. The desirability of remunerative side lines for the saddler and the reason for it have been already urged. Leggings and gaiters are very profitable, and dog collars, leads, chains, baskets, and clothing are very saleable if a little less remunerative. Bags and portmanteaus are intimately allied to the trade, and should by all means be put into stock. They are discussed in the article on Bag and Trunk Dealers in this course, to which attention is directed. Game bags, cartridge bags, gun cases, braces, belts, and footballs can all bring grist to the mill and profit to the till. Driving gloves are articles of frequent demand, and yield good profits. Saddler-made purses have a reputation for long life which they deserve, and are not to be despised; but they are given to last too long, and when we hear of one which has stood the strain of daily handling for twenty years, one feels that the benefit has been all with the purchaser and not with the saddler who made and sold the article.

Credit and Profits. As already mentioned, the business is chiefly of the credit order, and yearly and half-yearly accounts are the rule. The trading, both on the sales of articles bought and on the manufactured work, should show a gross profit of about 33⅓ per cent. on the return. Repair work ought to be more remunerative, chiefly for the reason that the proportion of material used is generally small, and the price is made up of labour which should always carry larger profit than merchandise.

The objectionable practice of bribing the servants of customers has become common in the saddlery trade. Once adopted, it is most difficult to abandon, and the best course is to refuse to countenance it in any form. The man who takes this stand will maintain his self-respect, win the respect of his customers, and find it remunerative in the end. The new law which has come into operation (January 1907) ought to suppress the practice if it is rigorously enforced.

Continued

OBOE, COR ANGLAIS, & BASSOON

Construction of the Instruments. The Players' Attitude. Compass and Tone. Scales. Effects and Exercises

Continued from page 4791

By ALGERNON ROSE

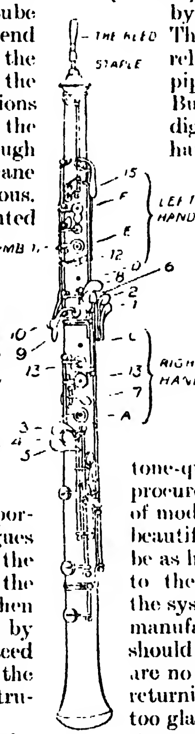
OBOE

When "reeds" are referred to in an orchestra, they are of two kinds—single and double. The single reed is that which vibrates against the framework of the mouthpiece (referred to in the article on the Clarionet). Of the double reed family, the chief member is the Hautboy, or, in Italian, "Oboe." Here the tone of the instrument is elicited by blowing through two slips of pliant cane, placed one against another in such a manner as to leave a narrow channel between them for the passage of the breath.

Two tongues, bound firmly together with silk, are fastened over one end of a thin metal tube known as the "staple." The opposite end of this staple fits into the upper orifice of the hautboy itself. According to the size of the instrument and its pitch, so do the dimensions of the double reed vary. In choosing the reed, appearance is the only guide, although this is not always a sure one. The best cane is of brilliant yellow, with the bark lustrous. Pale cane gives bad tone. What is wanted is a reed neither too hard nor too soft. The former sounds unpleasantly shrill, whilst the effect of the latter is woolly, and lacking in vibration. Good hautboy players are generally adepts at making their own reeds, because no one can judge so well as the player himself what best suits his own lips and teeth.

An ideal reed possesses justness, exactness, and equality in vibration. These requirements depend, of course, not alone on the colour or the fibre of the cane, but on its precise length, thickness, proportions, and the way in which the two tongues are disposed opposite each other. As the charm of the hautboy greatly depends on the good quality of its tone, and as this, when the double reed is once fixed, is governed by the manner in which the latter is placed between the lips and blown by the player, the performer's attitude, when holding the instrument, is of no small importance.

Attitude. If the hautboy is held like the clarionet, the student will neither do justice to himself nor to his instrument, because there is as much difference between blowing a tube with a single and a double reed as there is between firing off a gun with a single and a double barrel. The idiosyncrasies of each implement, whether as regards tone or trajectory, must be studied. Place the hautboy in a straight line from the mouth, then let it slant downwards till the right thumb, holding the middle portion, is about six inches from the body. Keep the head erect. Rest the hands lightly on the instrument and point the fingers downwards—not upwards, as for flute playing. The left hand negotiates the top joint, and the right hand the middle joint. Do not rest the second joint of the first left finger on the instrument. This habit spoils freedom in playing. Remember that there must be no stiffness in manipulation. Curve the fingers. Raise them above the holes, just sufficient to allow the air to escape. If the fingers are lifted high it is impossible to get rapidity in execution. A peculiarity in hautboy playing is that the holes must not be covered by the tip of the finger, but, as in the bagpipe, by the fleshy part of the first joint. This is interesting, because it shows the relationship of the hautboy and the bagpipe chanter to the pastoral musette. But, unlike the bagpipe, which requires digital strength of a steely character, the hautboy as a solo instrument, especially in the orchestra, demands a combination with force of the maximum delicacy if the peculiar sweetness of its tone is to be produced in a flexible manner, so that the intermediate shades and varieties of expression may be controlled artistically.



THE OBOE (Rudall, Carte & Co.)

Choice of Instrument. The material of which hautboys were formerly made was frequently boxwood. To-day it is agreed that either rosewood or ebonite gives not only a fuller, but a more delicate tone-quality. The student should be able to procure a reliable second-hand instrument of modern type for £5, or less. For the most beautifully finished new models the price may be as high as £40, the cost varying according to the number of keys, the material, and the system on which the instrument has been manufactured. If the hautboy is not new, it should be carefully examined to see that there are no cracks in the tube. A bandsman, on returning from India, will sometimes be only too glad to dispose, very cheaply, of an instrument, the tube of which has split in the tropics, or has developed other faults. These occur most frequently in boxwood or ebony instruments, which are very brittle, and liable to go wrong if dropped.

The hautboy is far more sensitive than the larger orchestral wind instruments. It is therefore very delicate. But the beauty of its tone, when mastered, more than compensates for the care the possessor has to bestow upon it. The student should therefore resolve, from the beginning, to strive to obtain the most expressive sound-quality,

and always improve upon it. Once a bad tone-production has been acquired, there is nothing more difficult than to get rid of it. A remarkable feature of this little instrument is that its shrill and piercing character will cleave its way through the tone of a hundred violins. If well played, it will stand out like a thread of finely-spun gold on a groundwork of velvet-pile. On the other hand, it will be like vitriol if the instrument is blown in a wrong way, although this very stridency of its tone makes the hautboy invaluable in a military band when leading troops.

The Tone. The soul of sound is put into the instrument not, as in the case of the violin, by the right hand, but by the mouth of the player. The tongue and breath of a wind instrumentalist do all that the violin bow achieves on a stringed instrument. When treating of the violin, however, we have seen how much has to be accomplished by the bow. If, therefore, execution on the hautboy is to be brilliant, sympathetic, and effective, much depends on the correct way in which the tongue and the fingers of the player harmonise together. Before inserting the reed in the mouth, draw the lower and upper lips over the teeth. This makes a soft cushion on which the reed may rest. Place the tip of the reed in the middle of the mouth, not so far as the staple, but about one-third of the length of the cane. Fix the reed in such a way between the lips that it may not alter its position. As in the clarionet, the pressure by the lips on the reed is slack for the low notes, and firmer for the high ones.

Having inserted the reed in the mouth, let the tip of the tongue touch the end of the cane. It must do this so as to close, temporarily, the channel of air between the two slips of cane which form the double reed. Fill the mouth with air by drawing a long breath. Compress the cheek muscles sufficiently to cause the reed to vibrate. Withdraw the tongue quickly, so that the breath passes between the reeds with moderate force. This method of attack in the tone is technically known as "tonguing."

This delicate instrument needs considerable care. After each time the hautboy (or oboe) is used wipe it out by means of a piece of silk wrapped over a stick. Occasionally the joints need greasing. For this purpose mix together a little melted beeswax and tallow. If the points of any of the springs squeak, put on a drop of sewing machine oil with a feather. Always keep the screws of the keys tight. Should a key fail to act, carefully unscrew it, clean it with leather, and replace it. When the instrument has been taken apart and put together again, make sure that the finger-holes are in an exact line. In adjusting the reed into the headpiece, the oval part of the reed should be parallel with the fingerboard.

If the reed does not vibrate freely, scrape it till it becomes more transparent. Do not make it too thin, or the top notes will be very difficult to produce. In that case, slightly curtail the end of the reed. With a sharp knife cut off a piece very smoothly. According to the character of the note required, so must the attack of the tongue be strong or weak. The more advanced the student gets in his studies the more mindful should he be of the object to which he is endeavouring to attain. He should aim at a beautiful tone-quality rather than mere rapidity of execution. It is well to imagine that a severe critic is always listening to one's practice.

The two lips of the player and the two lips of the reed should work together with such harmonious flexibility that the fact of the initial vibration being due to the pulsations of air forced between the reeds from the lungs should be dismissed from the mind of the performer.

The Breath. Make no noise in taking a fresh breath. Keep the body still. Because of the tiny aperture in the reed, the performer feels that he cannot breathe freely into his instrument, and has a sense of holding back wind which is not fully used. But one mistake which beginners are apt to make is to employ more breath than is necessary. Since the aperture in the reed is so small, the art is to supply just as much air as is required, and no more. As soon as he has mastered the playing of single notes, taking a fresh breath for each sound, the player should endeavour to link together a group of notes so as to make a musical sentence by one respiration. It is because of the breathing difficulty that frequent pauses are given in hautboy music, during which the player can exhaust, or reinforce, his lungs. The hautboy player, if he desires to excel, must carefully study the management of his breath. At the beginning of a phrase, sufficient air should be inhaled to suffice for the number of notes slurred together. If a habit of reading ahead is cultivated, breath-control will give little trouble. The careless player, who reinforces his lungs unnecessarily for a short passage, and omits to do it before a long one, soon becomes fatigued and exhausted.

A long phrase on paper does not always demand as much breath for its performance as a comparatively shorter one. If the former is played softly in quick time, and the latter loudly in slow time, the shorter group of notes will require, obviously, a larger reserve of wind power. Avoid taking a fresh breath in the middle of a phrase. If this is necessary, inhale what is called a "half-inspiration" quickly. In such cases it is better to have too much breath than not enough, because if, when the player reaches the middle of a phrase and finds he has more than he needs, there is little difficulty in letting the surplus escape, so long as he takes care to reserve enough for the completion of the passage.

Compass. The compass of the hautboy is two octaves and four notes, from B below first ledger line treble clef to F above third ledger line over the staff. But the best notes are from G, on the second line to C on the second ledger line above staff. If we reckon by the church organ, the hautboy, from its lowest C to the B above, gives what is known as the "two-foot" tone. But as two semitones belonging to the four-foot octave are produced by additional holes near the bell, the measurement somewhat exceeds 2 ft. from end to end. This extra length considerably

enriches the tone-quality of the instrument, which formerly was shorter than it is to-day. As the hautboy is difficult to play when on the march, its parts, in military music, are written as simply as possible, rapid passages and arpeggios being avoided. In a brass and reed band, however, a couple of hautboys sustaining notes in the harmony considerably add to the effect of the general tone. For solo playing the student must prepare himself to execute a good many complicated passages. Nevertheless, the hautboy appears at its best when it is given in the orchestra a plaintive melody of a pastoral character. Unlike the clarionets and flutes, it sounds the actual pitch of the notes written in the music.

Hautboys possess 12, 13, 16, 17, or 19 keys besides rings. The prices range, for new instruments of rosewood or ebonite, from £8 to £10. The model most generally used has 15 keys and two rings, and costs about £10. Instruments of the latest pattern give the low B♭.

Fingering. As regards the fingering, there is considerable resemblance in the hautboy to the flute. The natural scale of the tube, if no keys are used, is D major. With the keys, C♯, C, B, and the low B♭ are produced beyond the ordinary holes by means of additional vents pierced in the lower part of the tube. From the B♭, therefore, to the extreme top of the compass, this instrument gives not only the diatonic, but all the chromatic intervals, those above the first octave being obtained by increased pressure of the breath. This acceleration of the vibration within the instrument causes the upper harmonic partials to sound. The highest notes are elicited by cross-fingerings. Unlike the clarionet, the hautboy does not, however, jump off in tone a twelfth higher with extra blowing. The increased force supplied produces the octave, as in the flute, over the lower notes played with slacker lips. Although the tone of the instrument cannot be described as resonant in volume, it has a peculiar, penetrating quality so that, unless carefully produced, the sound is unpleasantly nasal and piercing. To understand the fingering, the first point is for the student to locate the six open holes. In the cheaper models none of these have rings. Refer now to the illustration.

Starting at the top of the instrument, these finger-holes are marked F, E, D for the left hand, and C, B, A for the right. Being in the upper part of the tube, the holes are conveniently under the fingers of the player. Rest the instrument on the right thumb by the plate provided for the purpose at the back of the joint. Put down the first left finger over the F hole, the second left finger over the E hole, the third left finger over the D hole, and close the C, B, and A holes respectively by the first, second, and third right fingers. In modern instruments certain keys have double branches. Thus, the fourth left finger, touching No. 6 key, or the left thumb touching No. 10 key, by opening the same vent, enables some otherwise difficult passages to be played with ease. Having closed all the six holes, put down as well the first, second, and fourth keys. Blow softly, and this will give the lowest note, B♭. For the B♮, use the same fingering without the first key. For the low C employ the same fingering, but with only the fourth key.

Close all the holes likewise for the C♯, but only use the third key. For D♮, close all the holes, without using any of the keys. For the D♯, or E♭, keeping all the holes closed, either the fifth or sixth key may be employed, as most convenient. To produce E♮, open the lowest hole, keeping the others closed. In the same way, F♮ will be obtained with the addition of the seventh key. F♯ is played by opening the fifth as well as the sixth hole. For G♮, open the fourth hole. Keep this fingering for G♯, adding the eighth key. For A, open the third hole. Use the same fingering for A♯, adding, as convenient, either the ninth or the tenth key. For B♮, close only the top hole. For C♮, close only the second hole, or the first, with the eleventh key. Blowing with more pressure than for the lowest register, put down the fingers on all the holes again, excepting the top one, for C♯, and use the fourth key. Or leave all the holes open, and use the fifth key.

A third way to get this note is to put down the first finger on the top hole, and use the twelfth key. To get D, on the fourth line, close all the holes except the top one. For D♯, keep to the same fingering, but *half* cover the top hole, and use either the fifth or sixth key. For E♮, open the bottom hole, keeping the others covered, and add the thirteenth key. For F♮, keep the same holes closed, but use the seventh key. Open the two bottom holes for F♯, using the thirteenth key. For the G♮, open the three bottom holes and put down the thirteenth key. Use the same fingering, adding the eighth key, for G♯. For A♮, open the four bottom holes, using the thirteenth key. Cover all the holes except the third, and add the thirteenth key for A♯. For B, cover all the holes excepting the second, and add the fifth key. Or, if more convenient, only cover the top hole, using the fourteenth key. For C, cover all the holes except the first and sixth. This is an example of what is called cross-fingering. For C♯, add the fourth key.

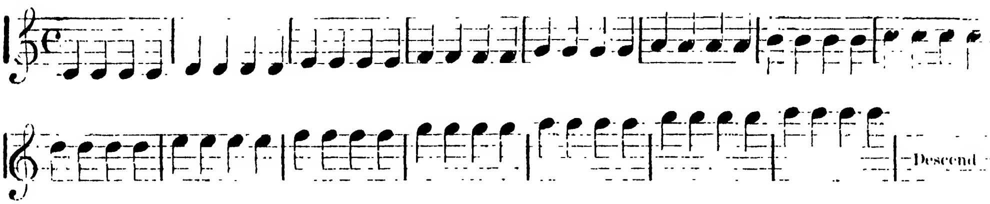
Open the third hole, *half* cover the top hole, and still use the fourth key, for D. For D♯, adhere to the same fingering, but close the bottom hole and use the second instead of the fourth key. For E, half close the top hole, quite close the second, third, fifth, and sixth holes, leaving the fourth open, and using the fifth, eight, and thirteenth keys. For F, *half* close the top hole, close the second hole, the fifth and sixth, using the fifth, eighth, and thirteenth keys. For F♯, *half* close the top hole, close the second, fourth, and fifth holes, using the fourth, seventh, eighth, and thirteenth keys. For G, on the fourth ledger line above the staff, close the top and fourth holes, blowing with special force.

If the student following these directions makes out for himself a diagram such as we have furnished for the clarionet, he will well impress the method of manipulation upon his memory. Some notes, however, have quadruple fingering;

but to avoid confusing the beginner, every possible combination has not been pointed out. Although to get the two-foot tone for the low register slower vibration is passed into the reed, so that the whole of the air in the tube may form one long segment, for the one-foot tone that segment is harmonically divided by quicker pulsations until the top notes, which lie in the six-inch octave, are reached. By practice a crescendo can be obtained on the lowest notes, or a diminuendo on the highest, without in any way interfering with the pitch.

breath is taken in, playing successively C, D, E, and F; G, A, B, and C; and so on up and down the scale. Do not be satisfied till the two octaves can be played from low to top C in one breath, and from the top to the bottom in the same way. From C major proceed to G major. Treat that key in like manner. Next try D major with two sharps; A major with three; E with four, and so on, treating each key in the same fashion. Continue by studying the Relative Minor scales, beginning very slowly with A minor [Ex. 2]

Ex. 1.



Scales. For the study of correct articulation the daily practice of scales is indispensable, both ascending and descending. First try these diatonically in tones, with occasional semitones, and then chromatically, only in semitones. Both the major and minor scales should be studied. Play these at first very slowly, and listen attentively so as to get a good quality of tone. When this has been mastered, accelerate the speed to obtain rapidity of execution. But tone-quality should always come before velocity.

Here observe the F♯ and G♯ in going up, and the G♮ and F♮ in coming down. With diligence, the student must familiarise himself equally with the Minor as with the Major modes of each key. The accidentals introduced will also make practice of chromatic passages easy. Management of the breath being so important in hautboy playing, and modern music being so prone to semitones rather than whole tones, particular attention should now be given to the chromatic scale.

Ex. 2.

Try the scale of C major, through two octaves, descending, after ascending, in the manner given. [Ex. 1.]

Here we have four crotchets in each bar, repeating the same note. Practise this exercise with the metronome set to 40. This is the lowest time marked. Then, instead of crotchets play quavers, so that to each beat two notes are blown, and the same sound is made in each bar eight times. Without altering the metronome,

Chromatic Playing. Exercise 3 gives a passage in which no fewer than twenty-five notes are linked together by a single slur, indicating that they are to be played successively in one breath, the fingers meanwhile running up the scale through two octaves by a series of half-tones above the low C. To execute repeated passages like this requires considerable skill.

Taking this passage, the student should first link each two notes together. Thus, play the

Ex. 3.

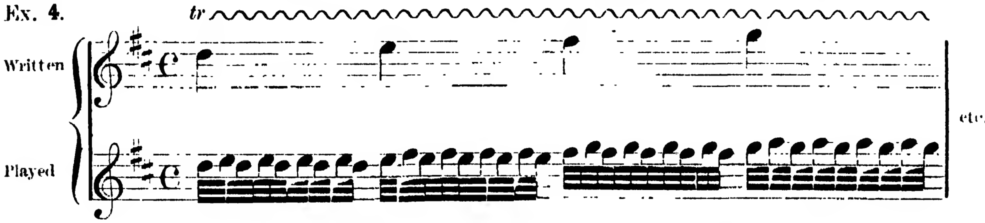
but quickening the stroke of the tongue, then try semiquavers. Four sounds to every beat will now be produced, so that each note is repeated 16 times in every bar. Then take the scale in a different way. Write it out on music paper without repeating any note.

Practise linking one note with another. Blow the C and B, the E and F, and so on, each coupled with one breath. Then make a slur over every four notes, so that no fresh

low C and the D♭ smoothly with one breath. Repeat this four times in one bar. Take the D♭ and D♮. Repeat them in the same way. After going up and down the two octaves in this manner, put an imaginary slur over every three notes. Play C, D♭ and D♮ in one breath, so as to make four triplets of the same sounds in each bar. Next link D♭, D♮, and E♭ together. Repeat them in the same way, and go up and down the chromatic scale, always

shifting the first note a semitone at a time. Having linked together three half-tones, try four. Take D♭, D♮, E♭ and E♮, in the same way. Next group five notes together, then six, and afterwards seven. By this manipulation and breath control are acquired simultaneously. Moreover, writing out such exercises is excellent training for familiarising the eye with musical manuscript. This often distresses an amateur, who has confined his attention to printed notation. When he first begins to play a second-oboe part in an orchestra, unless he has accustomed himself to manuscript exercises, he is placed at a disadvantage, and is unable to decipher the handwriting of the part given him. Continuing this study, group together, now, eight semitones—*viz.*, C, D♭, D♮, E♭, E♮, F, G♭ and G♮. Play that passage with one breath on the first beat of the bar. Repeat the same phrase on the "two," "three," and "four." Start the next bar from the D♭; the third bar from the D♮; and so on. Never be satisfied until every sound in each phrase is articulated clearly and in a flowing manner. Now link together nine notes from the C to the A♭ inclusive. Then ten half-tones, from the C to the A♮; eleven from the C to the B♭; twelve from the C to the B♮; and then thirteen from the C, including the C above. By this time the beginner will have mastered playing with one breath a complete octave. While he should not rest content with this, he should not make the mistake of attempting the impossible. What appears difficult at first will become easier with repetition, provided the time devoted to daily practice is carefully planned.

Ex. 4.



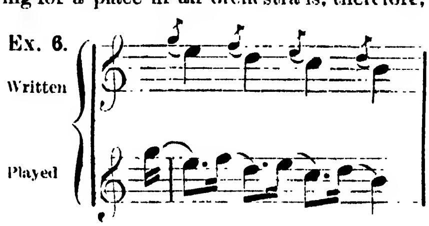
The Trill. The *shake*, or *trillo*, is the alternate repetition of a note written with one the next degree in pitch above it, and needs careful practice [Ex. 4].

Take the scale of D major, and play it slowly. Now, after the D, articulate the note above, E. Repeat the D and E four times, ending with the D. Proceed with the E, linking it with F♯. Repeat E, F, as indicated, before going to F♯ and G; G and A; and so on, up to the D and E above. The shake depends for its charm upon the evenness and smoothness with which the waves of sound are elicited. Familiarity with *chain* shakes will make what are known as *passing* shakes simple [Ex. 5].

Here, where the turn occurs over the G, the player inserts the A above and repeats the G quickly, making a little triplet on the third note of the group of four, without interfering with the time. *Appogiaturas* are slipped in much in the same way, the *Grace* notes being written small so that the larger notes may be more emphasised [Ex. 6]. A good player can do practically any kind of solo work with this instrument, which is capable, in its medium compass, of rapid execution and considerable liveliness. The ambitious student who takes up the oboe with the object of qualifying for a place in an orchestra is, therefore,

Ex. 5

Ex. 6.

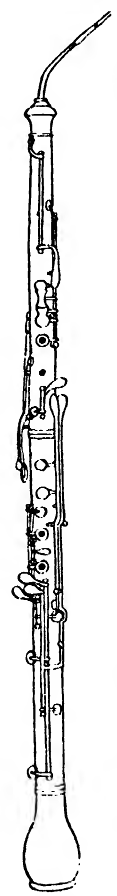


recommended to study the oboe parts of standard orchestral works: Haydn's "Seasons" and Symphonies, Mozart's Symphonies; the solos which occur in Beethoven's "Pastoral" Symphony, and in Rossini's "William Tell"; or in other familiar operas. such as Weber's "Oberon" and "Freischütz," and Auber's "Masaniello."

COR ANGLAIS

What the basset horn is to the clarionet, the cor anglais is to the hautboy.

Between the two instruments, however, come two instruments of the same double-reed family. First, we have the Oboe da Caccia, for which there is a part in Bach's "Christmas Oratorio"; secondly, we have the Oboe d'Amore, to-day used in the Bach Choir, at the Brussels Conservatoire, and elsewhere. This stands a minor third lower than the ordinary hautboy. It is, therefore, like the A compared to the C clarionet. The tube being longer, the lower notes are mellower, and, as was formerly considered, more sentimental; hence the name. But when parts occur in reading old scores marked "Oboe d'Amore"



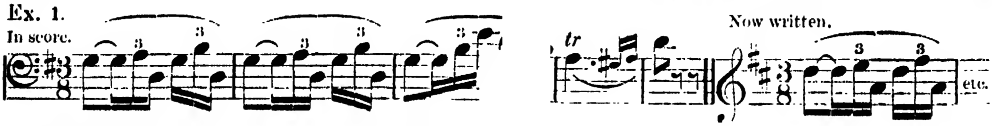
THE COR ANGLAIS (Mahillon & Co.)

or "Oboe da Caccia," they are usually transposed and played either on the ordinary hautboy or on the cor anglais. Of late years the latter instrument has been much improved, both as regards facility in fingering and purity of tone.

Cost. The cost greatly depends upon the make which the student desires to purchase. Complete, with leather sling-carriage and reed-box, a well-seasoned rosewood or ebonite oboe d'amore in A, with German-silver keys, new, can be obtained for about £10. A cor anglais, with 15 keys, in F, costs about £11. With 17 keys and real silver fittings, as much as 16 or 22 guineas, respectively, is demanded. In appearance, the oboe d'amore is like a big ordinary hautboy. But the cor anglais has the mouth-tube, to which the reed is attached, curved and bent towards the player. The bell, or bass end, of the instrument, instead of being concave, like the hautboy, is convex, or bulbous.

Fingering. Except that the keys are rather larger, and the holes somewhat further apart, the fingering is precisely the same as on the hautboy. The scale of the cor anglais is two octaves and a fifth—from E, third space bass clef, to B♭, first ledger line above treble clef. Such are the actual sounds produced. But if we examine one of the most familiar instances of the use of this instrument, which occurs in Rossini's Overture to "William Tell," we shall find the part given to the cor anglais in the score placed in the bass clef. This is the Italian custom. To-day, however, instead of representing the instrument an octave lower than its real sounds, the cor anglais is written for strictly according to the fingering, and treated as a transposing instrument [Ex. 1].

Ex. 1.



This arrangement of writing in the treble clef adapts the cor anglais to the ordinary hautboy fingering, so that the larger instrument automatically speaks its part as desired, a fifth below, in the same way as obtains with the clarionets. The key signature of the cor anglais always contains, therefore, one sharp more, or one flat less, than that in which the music really stands. When a part for this instrument occurs in an orchestral score, one hautboy only is usually employed at the same time, because the part for the second hautboy player is dispensed with, that being allotted to the cor anglais. He is thus spared, when the composer scores in the treble clef, the trouble of transposing his part a fifth higher. Standing in the key of F, and speaking a fifth lower than the ordinary hautboy, if the second hautboy player suddenly takes up the cor anglais, he has enough to do to suit his lips to a different reed and adapt his fingers to the larger key mechanism without having the perplexity of transposing at sight to attend to as well.

The Reeds. Although the rough-and-ready drone-reed of the Highland bagpipes in producing tone is the same in action as the hautboy, the pipe-reed does not come into contact with the player's lips. The more musical the oboist the more sensitive are his lips, and, for obtaining the different registers of pitch by variation of lip-pressure, it is necessary that the double reed, upon which the lips and the tongue operate, shall pulsate with the utmost responsiveness, so that the player may not be hindered by the cane being unduly stiff or soft. The reeds here are larger than those for the hautboy, but otherwise are alike in detail.

The Tone. For cantabile, or slow movements, the expressive quality of the cor anglais stands unrivalled; but the instrument is not adapted for rapid passages. When well played, its lower notes are rich and exceedingly beautiful. They possess a tone-fragrance which distinguishes this instrument from all others in the modern orchestra. For that reason composers make more and more use of the mysterious "colouring" which the cor anglais, judiciously used, gives to an orchestral tone-picture. To subdue the tone, it was formerly customary to cover the wood of the instrument with leather, which also prevented its cracking. But that idea has been discarded. Meyerbeer, in the "Huguenots," Gluck, in "Orpheo," Berlioz, in the "Symphonie Fantastique," and Halévy, in "The Jewess," have all employed, with telling effect, the low, plaintive, mysterious sounds of the cor anglais.

Beethoven has a fine trio for two hautboys and cor anglais, Op. 29, and, in the opening of Act III. of "Tristan," Wagner uses the instrument in a masterly manner. But all these instances are for sustained effects. So, although the cor anglais is the outcome of a rustic pipe, it is not adapted for lively melodies. For the beginner, who can use it in place of the hautboy, it is of considerable advantage to learn, because he must be prepared to take it up at any time if he becomes an orchestral performer.

This article would not be complete without mention of the fourth member of the family, the Oboe Basso, now obsolete. This, however, was almost synonymous with the oboe lungo, or oboe d'amore [see also OBOE].

BASSOON

On account of its human quality of tone in the higher register, the bassoon is frequently called the "Vox Humana" of the orchestra. In some respects it is singularly like the violin, because the musical ear of a player is mainly responsible for correct intonation. Moreover, an old bassoon, like an old fiddle, improves with age. By reason of its delicacy and sensitiveness, this instrument endears itself in a remarkable way to the player. If he attempts to force its

tone he gets out of it nothing but a succession of grunts or squeals. It will not be coerced, but can be coaxed into doing many charming things. By employment of this instrument, Haydn, Bach, Beethoven, Mendelssohn, and other great composers have achieved wonderful effects. Unfortunately, the bassoon is not always reverenced by musicians as it ought to be. It is looked upon as the clown of the orchestra. But, although Mendelssohn has made it imitate closely the braying of an ass in the "Midsummer Night's Dream," in funeral marches it is used with awe-inspiring effect.

It is because of the spiritual qualities of the bassoon that the player who wishes to qualify for an orchestra should possess exceptional, rather than ordinary, musical gifts before he seeks to excel in it. If the student has an opportunity of hearing a soloist like Mr. James, the principal player in the London Symphony Orchestra, he will realise how expressive is the bassoon when artistically treated.

The Dulcino. In orchestral scores this instrument is generally designated by its Italian name, "Fagotto." This, in old writings, is spelt "Phagoti," from "phagos," a faggot, the appearance of the instrument being thought to resemble a bundle of sticks. The part it plays is an octave below the cor anglais, and a twelfth —not an octave, as is generally thought—below the hautboy. In Italy, a boy is put to the bassoon at the age of ten. He is given the small model, known as "Dulcino," to play. On account of its size, this is more suitable for his fingers. Then, after two or three years, he can take up the ordinary-sized bassoon, just as a child who has learned the rudiments of violin playing on a half or three-quarter sized instrument can go to one of full size.

The ordinary bassoon is, in reality, a tube, mostly of wood, eight feet in length. As an eight-foot pipe would be unwieldly for the player, this is doubled up.

The Parts. The bassoon consists of five parts, known as (1) the crook, (2) the wing, (3) the butt, (4) the long joint, and (5) the bell. Fitted together, these parts form a carefully graduated hollow cone. This tapers from a fraction of an inch at the reed to less than 2 in. diameter at the bell. The extreme end, however, is not the widest internal part of the instrument. Like the cor anglais, it is made bulbous, the extremity being constructed so as to subdue the effect of the bell-note. By doubling the tube, the instrument itself measures only 4 ft. This places all the holes within the reach of the fingers, the vents being pierced obliquely through the substance of the wood, so as to bring them more conveniently under the two hands of the performer. The small brass tube, which resembles a Latin "S," gradually increases in size internally, being fixed at its wider end into the wing. The latter is also known as the *tenor joint*. The wing, in its turn, fits into the butt. This is called, also, the *lower joint*. Here the bore is bent back upon itself through a solid block of wood in the shape of the letter "U," the base of the "U" having in it a cork, or sometimes a sliding tube, from which the condensed breath of the player can be emptied. The lower joint, or butt, fits into the long joint. This is termed, also, the *bass joint*. On the top of the latter is fixed the so-called "bell," also known as the *small joint*.

Having built up the parts, let us look at the keys. Three of these are fixed to the wing, or tenor joint. The longest key is the C, the short one A, and the third, pointing downwards, C♯. These are all worked by the left thumb. In the butt, or lower joint, the first key is B♭, the second E, the third F, and the fourth G♯. The right thumb manages all these. The first right finger negotiates the B♭ key, connected with the first-mentioned B♭, controlled by the right thumb in the same way that the third right finger has control of the open key in A, worked also by the left thumb. Beside the open A key are the keys of G♯ and F. Above the F is another key controlling F♯. These three—G♯, F, and F♯—are managed by the right little finger. In the long, or bass joint, the left thumb works the first, or open D key. Then come E♭ and C♯, both negotiated by the left little finger, as well as the two last keys, B and B♭, the two latter, together with the open top C, being managed by the left thumb. Bassoons have 16, 17, 19, or 22 keys, according to their system of manufacture. The ordinary model has the 17-key mechanism.

Compass. The compass is from B♭, second ledger line bass clef, to A♭, second space treble clef; but extra key-work and cross fingering enable the F above to be reached. Thus we have a remarkable range of three and a half octaves, giving the entire chromatic scale, some notes having triple fingering. Music for the bassoon, consequently, is written in the bass clef, the tenor, and, occasionally, the treble clef. But the action of the player's lips has a great deal to do with producing notes of different pitch with similar fingering. What is known as "loose lips" is employed, if we begin at the lowest note in the bass, up to the lowest G. From the A, first space bass clef, the B, C, D, E, and F, with their semitones, are played with what is called the *natural embouchûre*. On the G above comes what players call a "change." For this note the lips are "pinched." They are drawn in more and more the higher the pitch becomes in ascending the scale, so that for extreme top notes considerable pressure is needed.

Reeds. This humouring of the notes by the lips makes the choice of reeds a matter of importance. If the cane is unripe, it will be spongy and give a poor tone. If it is ripe, it will be of golden colour. The cane should, preferably, come from Southern Italy rather than the South of France, the former having more resilience. Bassoon reeds can be purchased at music shops from a shilling upwards. "Guaranteed" reeds are to be had from two shillings, singly, or thirty shillings a dozen.

Attitude. The chief weight of the instrument is thrown on to the player's left shoulder by means of a leather strap. This is fastened

by a swivel through a metal ring at the lower joint in the second band below the wing. Hold the instrument obliquely from left to right in the hollow of the hands. The bell must point upwards in the direction of the left shoulder. Place the left hand at the level of the player's breast, and the right hand lower down. The lower portion of the instrument should come behind the player's right thigh. Keep the body erect, and the head upright in a natural position. The bassoon crook should be turned slightly towards the right. Do not move the elbows to accentuate fresh phrases.

Draw the lower lip over the teeth, so as to form a cushion. Before fixing the reed into the crook, moisten the former. Now put the reed in the mouth. Place it between the middle of the lips, so that both lips press against the flat sides of the reed. In this way it must be held securely, and not allowed to shift when the lips tighten or slacken for the production of high or low sounds. The left side of the reed should point slightly upwards, so that it rests in the mouth obliquely. Let both lips cover it nearly as far as the first ring of wire.

The First Sound. With the left hand, close the first, second, and third holes in the wing, or tenor joint, by the first, second, and third fingers. Having done this, shut the aperture between the reeds by projecting the tongue. Take a full breath, but do not puff out the cheeks. Whilst neither pinching the lips unduly, nor letting them become loose, pronounce the word "too." Articulation of this syllable will cause the tongue to retire swiftly from the reed. This will force the air through the aperture. The result will give C, second space bass clef. As soon as this note is elicited, sustain it while counting mentally four beats in slow time. Make the tone of equal strength, and do not allow it to jump off either to a higher or lower pitch [Ex. 1].

Ex. 1.

How comparatively small is the diameter of the long air column, which pierces this bulky, doubled-up wooden instrument, is not usually realised. Take any other tube in the orchestra giving an eight-foot tone, such as the euphonium or bombardon, the metal of which is hammered thin, and it will be perceived that the air column in the latter is far more ample than in the former. It is this fact, combined with the initial vibration of the double reed, which gives the bassoon its characteristic tone. The tone-quality of a wind instrument is governed, first, by its embouchûre, or manner of the blowing, and, secondly, by the dimensions and length of the internal air-column, rather than the thickness or special substance employed to enclose that column. The student will, therefore, understand how important it is that the internal passage of so delicate an instrument should be kept clean.

A bassoon requires almost as much nursing as a rifle in which smokeless powder is used if it is to be handled with the best effect. When dirt accumulates inside, it not only flattens the pitch but the articulation becomes false, and some notes are very difficult to produce. The student when he has finished his daily practice should invariably turn the instrument upside down to let the water run out. In addition to this, whenever there is time, take each joint apart to let the air penetrate through the tube. Wipe it out carefully by pulling a worsted cleaner through every joint. If the instrument is put away damp, the wood will swell and soon rot. Every three months it needs careful overhauling.

This should be done after it has been practised upon for some hours. If the instrument has been put aside for some time, it cannot be cleansed so satisfactorily. Having taken the joints apart, clean out the crook by passing a long quill through both ends. Then withdraw the quill, and fill the mouth with clean water. Blow it through the crook until the tube is thoroughly washed. Pass a wad of linen tightly through each joint to take off the thickest layer of dirt. Take out the cork, or sliding tube, in the butt. Carefully take off the keys, or the pads will be spoilt by the next operation. Now introduce a quill dipped in the best salad oil Having oiled each joint, *excepting the crook*, allow the instrument to stand for a whole day, so that any unnecessary accumulation may be thoroughly soaked. Wipe out afterwards each joint with some dry linen until it comes through unsoiled.

The Fingering. Having produced the first sound, C, by blowing steadily through the reed, closing the first, second, and third holes in the wing of the bassoon, the student should now proceed to connect the C with the D above, the E and F, with the B below, and so on. If the student follows the succeeding indications, and turns to the chart in the Clarionet article [page 4790], he can make out a similar one for the bassoon. This will impress the fingering on his mind. The six open holes are stopped, as has been noted, by the first, second, and third fingers of the left and right hands, the former negotiating those in the tenor joint, or wing, and the latter those in the lower joint, or butt. In addition to the holes, in the ordinary mechanism there are seventeen keys, to which system we will confine our attention.

In any case, the majority of the keys are manipulated by the fingers of the left hand the right fingers being used only for keys 7, 8, 9, and 10. This is made clear by the illustration on the next page, which shows the entire instrument, with all the keys, front and back, with their numbers.

With this as a guide, we may learn how every note is produced in the compass, including all accidentals. But it must first be understood that the tone of the bassoon is capricious. Like the violin or the trombone, its correctness of intonation depends greatly on the musical ear of the performer. So much is this the case that every good bassoon requires different treatment. A first-rate player cannot, therefore, do himself justice on a strange instrument unless he is given time to become familiar with its peculiarities. Like the hautboy, the bassoon gives the

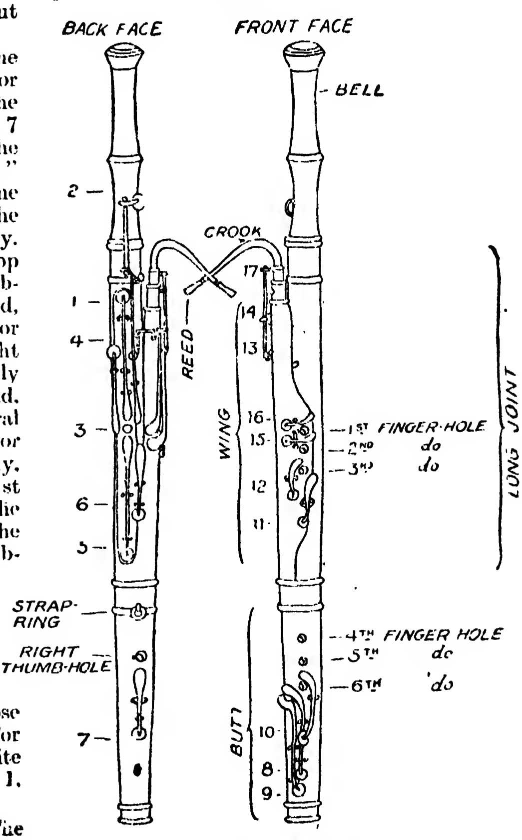
consecutive harmonics of an open pipe, its pitch being an octave below the cor anglais and a twelfth lower than the hautboy. Closing the three finger-holes for the left hand, the bassoon thus speaks C, whilst the hautboy would give G. Closing the six finger-holes, the bassoon, like the flute, speaks G, whilst the hautboy sounds D. But, unlike either the flute or hautboy, we have, below those closed notes, a range of deeper sounds in the bassoon, these being obtained below the natural scale of the instrument by means of extra vents near the bell, which nullify the effect of the constriction at that part so that the lowest note is not G. The bassoon gives no fewer than eight semitones below it, till B♭, second ledger line below bass staff, is reached.

The Lowest Notes. To produce this B♭, close all six holes and put down keys 1, 3, 5, and 8, as well as the right thumb-hole at the back of the bottom joint. Blow with a very loose lip. Having produced this note in slow time, to get B♮, keep to the same fingering, but add No. 2 key. Blow as before. For the bottom C use the same fingering, but release keys 1 and 2. C♯, or D♭ above, is produced by the same fingering as C, with No. 4 key added. D♮ is sounded in like manner, except that keys Nos. 3 and 4 are not employed. For D♯ or E♭ above, keep to the same fingering, adding No. 6 key. For E♮, use the same manipulation, without keys Nos. 5 and 6. Keep to the same fingering for F♮, but do not close the right thumb-hole.

For F♯, or G♭, add No. 7 key. Close the six finger-holes for G♮, but use no keys. For G♯, or A♭, add keys 5, 6 and 9. Release the third right finger for A♮, putting down No. 7 key. Here do not blow any longer with the loose lip, but use the "natural embouchûre" for the reed. For B♭, or A♯, keep to the same fingering, but release No. 7 key, closing the right thumb-hole and putting down No. 10 key. Another way of getting this sound is to stop all fingerholes except No. 5, closing right thumb-hole. For B♮, stop only the first, second, third, and fourth finger-holes, using No. 10 key; or close holes 1, 2, 3, and 5, together with the right thumb-hole. Now we come to C, which is easily produced by putting down the first, second, and third left fingers, and blowing in a natural manner. Merely add No. 11 key for C♯; or close the first, second, and fourth holes only, using No. 9 key. For D♮, put down the 1st and 2nd fingers only. D♯ is sounded in the same way, adding No. 12 key; or put down the first and third left fingers, closing right thumb-hole. For E♮, put down only the first left finger and No. 9 key; or, instead of this key, close the right thumb-hole. F♮, a semitone above, is the note sounded when none of the holes of the bassoon are closed nor keys are used. This, therefore, is the "open note" of the instrument. For F♯, close the three lower holes and add No. 8 key. For G♭, which on this instrument need not be quite the same as F♯, close all the holes except No. 1, using No. 8 key.

The "Vox Humana" Register. The reaching of G♮ (on fourth space, bass clef) carries us into a fresh harmonic region of the tube. As regards different qualities of tone, the management of the bassoon reed by the lips may be compared to the production of the voice in singing. From the lowest B♭ on this instrument to the G above we have the reed blown with a loose lip, in the same way that, for producing the deepest notes of the larynx, the singer allows his vocal cords to slacken and breathes abdominally. At this point, from the G, first line bass clef, the bassoon player uses the natural embouchûre, or lip pressure, on the reed, just as a singer gives a normal tension to his vocal cords when eliciting what are known as "chest" notes. Presently, from the G♮ in the fourth space to the extreme top of the bassoon compass, the tension of the lip on the reed will be increased, so that it is set into vibration in a manner called "pinched," analogous to the way the falsetto voice makes the vibrating segments smaller in the head notes.

Formerly great composers used the bassoon mostly in its lowest and normal registers; but, owing to improvements in the tuba, and other brass instruments, the higher register of the bassoon has been found to stand out in better relief by Wagner, Tschaikowski, Dvorak, and other modern composers, and the higher notes are given, in consequence, more and more prominence. The ambitious student, therefore,



THE BASSOON

should pay particular attention to producing, as beautifully as possible, the semitones, from the G to which we now refer to the octave G above, this being the "Vox Humana" portion of the scale. To produce this G, fourth space bass clef, close all the holes except the top one. Stop the latter to check the tone with the octave G below, slackening the lips for that purpose. As the scale is ascended in semitones, it is an excellent practice to check each fresh sound obtained by means of the corresponding octave-tone below.

To get G♯, use the same fingering as for G♮, closing all the holes excepting the top one, but adding keys Nos. 6 and 9. For A♮, close all the holes except No. 6. If the tone does not come readily, cover also the right thumb-hole. For the B♭, close the first five finger holes, using keys Nos. 6 and 10; or, close the bottom hole, leaving No. 5 open and not using No 10 key. For B♮, close Nos. 1, 2, and 3 holes and use No. 10 key.

Tenor Clef. It will be found that the notes for the sounds hitherto made are usually written in the bass clef. Now that we come to the ledger lines above the bass clef, composers find it more convenient to employ the tenor clef, with C on the fourth line. To produce this note, merely put down the first three left fingers, as for the octave C below, but tighten the lips. For the C♯, employ the same fingering, closing the right thumb-hole and adding No. 11 key; or close the first, second, and fourth holes, using No. 9 key. For D♮, close the first and second holes and use No. 9 key.

There are three ways of producing D♯ above. Close all the holes except No. 3; stop only the first and third holes and right thumb-hole; or close only the first and second holes, using No. 12 key. For E♮ (fifth line tenor clef), close only the first hole and use No. 9 key; or close all the holes except No. 2, using no keys. For F♮, close the second, fourth, fifth, and sixth holes, putting down Nos. 6 and 9 keys; or, close the first, fourth, fifth, and sixth holes, using Nos. 6 and 9 keys; or leave open all the holes, using No. 8 key. For F♯, close the second, third, fourth, and fifth holes, using No. 8 key. For G♮, close the second, third, and fourth holes, using No. 8 key. To get G♯, close only the second and third holes; or, in addition to these holes, close No. 5 and use the 5th key. For A♮, close only the first and second holes, using No. 13 key; or close the second, third, fifth, and sixth holes, using keys Nos. 5, 6, and 9.

For B♭, close all the holes, using keys Nos. 8 and 13. For B♮, close holes 1, 2, 4, and 5, adding keys 8 and 13. For the top C, put down the first and third left fingers and first, second and third right, closing right thumb-hole and using keys 8 and 14; or, with the same keys, leave the second and third holes open; or, with the same keys, close the first, second, fourth, and fifth holes. This example of cross fingering will show how much depends on getting well into the mind the exact pitch of the note to be sounded. For the top C♯, put down only the first left finger, using keys 9 and 14. For the D♭, stop also the fourth hole. For D♮, leave all the holes open, using keys 9 and 14. Leave all the holes open for E♭, using keys 9 and 15. For E♮, which needs considerable lip-pressure and strength of blowing, leave all the holes open, using keys 9 and 16.

The top note of all, F♮, is produced by closing the second and fourth holes. Accomplished players can still further extend the compass upwards, although it requires much practice But the notes are seldom wanted, because they can be executed more easily on the hautboy.

Exercises. Upon this groundwork the student should be able to construct various progressive exercises. There are many departments of study, proficiency in which can only be achieved by constant repetition and intelligent application. The beginner, as soon as his lips and lungs get fatigued, should stop practice. Many students do themselves more harm than good by practising too long at first. Practise slowly, in every key, first the major and then the minor scales.

Ex. 2

Two distinct methods of articulation are presented by legato and staccato playing In the former each note must glide into its neighbour, one breath being used for an entire passage. In the latter each note must be rapped out cleanly by the tongue-tip. Therefore the syllable "too" is only articulated at the beginning of a slurred group. In playing staccato, however, give a "too" for each beat of the rhythm as well as the first of the bar, as in Ex. 2.

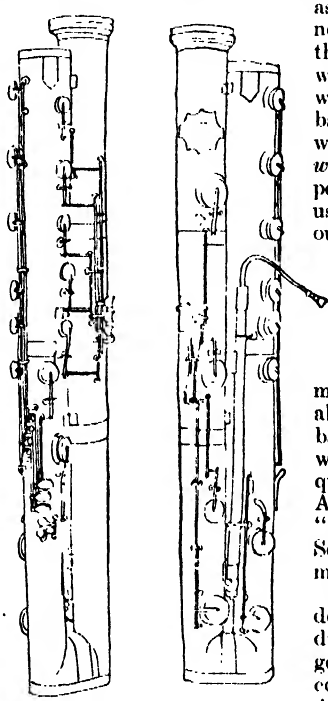
DOUBLE-BASSOON

Every ambitious bassoon student should cultivate also the double-bassoon; it strengthens the blowing powers of the lips, and thus improves one's tone-production. As is the case after exercising one's muscles with heavy dumb-bells and going back to those of customary weight, so the double-bassoon, when one goes back to the smaller instrument, makes the latter easier to articulate. The impressive grandeur of the contra-fagotto is often indispensable, particularly in the C minor Beethoven Symphony, Yet, in an average orchestra, bassoon players are seldom competent to perform the part.

In pitch, the double-bassoon is an octave below the instrument last described. There is, however, a demi-contra-fagotto in F, at an intermediate pitch between the ordinary and double-bassoon. But the instrument with which we now deal possesses an extreme compass of three octaves, containing every semitone

of the diatonic scale throughout that range. The top octave need not trouble the student, as parts are not written for it. The instrument consists of a conical tube upwards of sixteen feet long, the diameter ranging from a quarter of an inch at the reed to four inches at the bell. Nevertheless, this instrument is no longer, in appearance, than the ordinary bassoon. It is curved, not twice, but four times, so that it measures about four feet from end to end, and is thus conveniently manipulated by the performer.

According to the acoustical divisions of the tube, so are the holes pierced. To make the stopping and opening of these holes possible by the fingers, a special mechanism is provided. On the bassoon, "open" holes are operated on directly by the first, second, and third fingers of both hands. In the contra-bassoon, in place of these holes, saddle-shaped recesses represent the six open notes. These contrivances are situated so that three of them can be worked by the left, and three others, lower down, by the right, fingers. Instead of the tips of the fingers depressing these concavities, use for that purpose the middle joint of each digit. This is far less fatiguing to the player, as the holes are then closed with the assistance of the fore-arm muscles. The other keys—for sharps and flats—although larger than in the bassoon, are the same to the touch. As there is double the length of tubing, this is, of course, the heavier and more unwieldy instrument.



THE DOUBLE-BASSOON

Price. A double-bassoon costs no more than a pair of kettle-drums, and should be regarded, by societies, as of almost equal importance for enriching the tone at a public performance. An excellent double bassoon can be purchased for £15, but it is sometimes possible to get one at an auction-room for half that amount. Brass bands in the Midlands and elsewhere, desirous of winning prizes at the big competitions, can add considerable richness to their tone, and soften the harshness of other instruments, by utilising the splendid bass given by the E♭ contra-fagotto, now supplied in brass somewhat cheaper than the B♭ model in wood.

The reeds cost about 3s. 6d. each. The reed resembles that of the bassoon, but is larger. To secure accuracy of intonation, it does not require the same nicety of lip-pressure. This advantage enables an average bassoon player to accustom himself quickly to the larger instrument. No matter in what key the music is written, the double-bassoon, giving all the chromatic intervals, can execute accidentals as easily as naturals. There is no difficulty in discriminating the different notes by the touch without looking at the instrument when playing. Situated at the back of the lower joint, and worked by the right thumb, is the *water-key*. A double-bassoon performer should remember to use this key frequently, to blow out the moisture which accumulates. To preserve the instrument it should be cleaned out much in the same way as has been described for the bassoon.

Fingering. With the modern mechanism, the fingering is almost analogous to the ordinary bassoon, but the student who wishes to go further into the question is referred to the Appendix of Satzenhofer's "Neue Praktische Fagott-Schule," published by Zimmermann, Leipzig.

When properly played, the double-bassoon is capable of producing extraordinary effects. To get the lowest notes requires considerable practice. From the A written in first space bass clef, to the A above, sustained sounds are fairly easy. Rapid passages are undesirable, and almost impossible: but the deep throbbings of the low pedal notes are magnificent, as, for example, in Handel's "Firework Music," Haydn's "Creation," and Wagner's dragon music in "Siegfried." Indeed, most of the great composers have availed themselves of the deep double-bassoon notes. It should be remembered that the part written for this instrument stands an octave higher than the actual sounds, for convenience in notation.

OBOE, COR ANGLAIS, *and* BASSOON *concluded*

TELEGRAPH APPARATUS

The Germ of Telegraphy. Rules for Direction of Current. The Needle System. Conventionalisms in the Telegraph Service

By D. H. KENNEDY

ALL the principal systems of modern telegraphy are based on the relations which exist between current-bearing wires and magnets. These relations are discussed in the first seven articles on Electricity. It will be assumed that these have already been consulted by the reader.

In 1820, Oersted, experimenting with a battery and wires and a compass needle, found that when the current-bearing wire was brought near the compass the needle was deflected. It may be said that this was the germ from which has grown the immense system of telegraphic communication, and before proceeding with this section, the student should turn to the section on Electromagnetism [page 561], and thoroughly familiarise himself with every feature of this classical experiment. Figs. **20**, **21**, **22**, and **23**, on page 561, illustrate facts of fundamental importance.

Rules for Direction of Current. Mnemonics enabling the student to connect the direction of the current with the direction of the force due to its magnetic field are of great practical value, and there are several available.

Ampere suggested that we suppose a man to be swimming *in* the wire *with* the current, and with his face towards the compass needle. The N pole is deflected to his *left* hand. Maxwell preferred the "corkscrew" rule—namely, that the forward direction of the current and the direction in which a N pole is impelled are associated in the same way as the forward direction of an ordinary corkscrew, and the rotation of its handle.

Another simple rule is to look at the face of a watch, and imagine that the current is passing from the observer through the watch, from back to front. The resulting field would rotate a N pole in the same direction as the hands of a watch.

One of these rules should be selected by the student and fixed in the mind by thorough experimental testing, so that he will be able to determine the direction of the current in a wire from the deflection of a magnetic needle, or vice versâ.

The Needle System. In 1837, Wheatstone installed the first practical telegraph between London and Slough, and it is a remarkable fact that the same inventor subsequently produced the high speed automatic system which to-day is used to transmit nearly all our Press telegrams.

Wheatstone's original instrument survives in the shape of the *single-needle* telegraph [**6** and **7**, page 4385]. It is so named from the fact that the signals are read from the motions of a needle, and the word "single" is retained in the title because this type was evolved from predecessors having at first five, then four, and then two needles. Fig. **15** is a view of the dial of the receiving instrument. Normally, the needle is vertical, and, as indicated on the dial, the signals are made by various combinations of right and left deflections. The needle in front of the dial is non-magnetic, and merely acts as a pointer. It is, however, mounted on the same axle as the magnetic needle, which is placed in the centre of the receiving coils, as shown in **16**. The receiving instrument may best be considered as a direct development of Oersted's experiment. Imagine a small diagonal-shaped magnet mounted on a horizontal axis, and adjusted so that, normally under the action of gravity it remains vertical [**17**]. If we now bring a vertical current-bearing wire in front of the magnet, it will deflect to one side or the other according to the direction of the current. If the current is weak the deflection will be very small, but if we bring the wire over the top and down behind the magnetic needle at the same distance, we can double the deflecting force. Carrying the wire up the front again will treble the deflecting force, and, continuing the operation, we form a vertical coil, and we note incidentally that the deflecting force is dependent jointly on the strength of the current and the number of turns, or, as explained on page 562, on the ampere-turns.

For convenience, two coils are made, each containing an internal chamber large enough to allow the magnetic needle to oscillate. When they are fixed in position on the horizontal brass bar, the magnetic needle is entirely enclosed.

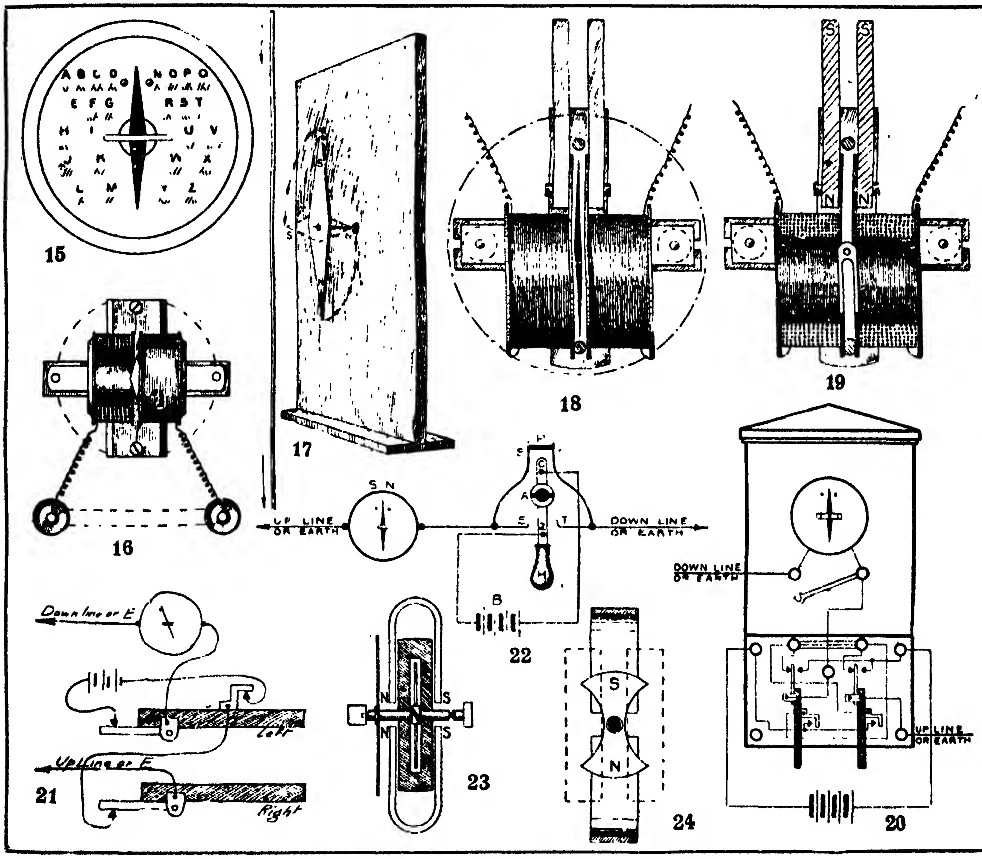
The instrument shown in **16** is not a modern form. It has been introduced to show the line of development. It was found that, owing to the joint effects of constant motion, and the demagnetising influence of the magnetic fields of the varying currents, the permanent currents rapidly deteriorated.

Varley's Induced Needle. The remedy was supplied by Mr. S. A. Varley, who, in 1866, devised the induced single needle shown in **18**. He provided two large permanent magnets, and substituted a small soft iron needle for the oscillating permanent magnet. The N poles of the two bars are brought down near the iron needle, so as to "induce" magnetism in the latter [**19**].

The single needle is one of a now large class of instruments which are sensitive to direction of current. They are called *polarised*. The "induced" method of Varley appears in nearly all polarised instruments. The student will

notice that the bar magnets have their N poles downwards, because in the northern hemisphere this direction is in agreement with the vertical component of the earth's magnetic field. The Varley form, in combination with a tapper commutator [see 6, page 4385], has been much used by the Post Office.

Depression of the left tapper connects the battery to the line, and sends a current in such a direction as to deflect the needle of the receiving instruments to the left, while the right tapper, on depression, makes the connection in such a way as to cause the current to traverse the



DEVELOPMENT OF TELEGRAPH APPARATUS

15. SN dial **16.** SN coil, early form **17.** Vertical magnetic needle deflected by field of current-bearing wire **18.** Varley's induced coil, showing signalling needle **19.** Varley's induced coil (section) **20.** Diagram of SN with tapper commutator **21.** Tapper commutator with left tapper depressed **22.** Drop-handle commutator **23.** Spagnoletti needle (side view) **24.** Spagnoletti needle (front view)

circuit in the reverse direction, which causes the needles to deflect to the right.

Circuit Diagrams. Fig. 20 is a diagram of the connections of a single-needle station. The student who is unfamiliar with telegraph connections may find it a little puzzling, and it may cheer him to know that those which follow are much more simple. In this, however, and all other cases, the really earnest student will not content himself with merely looking at the lines given here, and tracing them out. He should analyse each case for himself. Each wire shown in a connection diagram has some function to perform, and the student who takes the trouble to ascertain what it is usually finds that in the process his mind has taken such a grip of the subject as will enable him afterwards to reproduce the connections from memory. As an illustration, we may, in the case of the single needle, give a rough diagram [20], showing the state of things when the left tapper is depressed. Similar rough diagrams may be made to show the state of affairs when the right tapper is depressed and also when both are depressed.

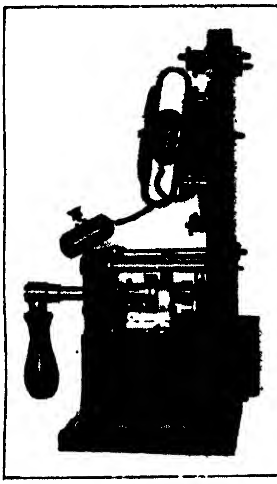
After this exercise there will be no difficulty in seeing that the object in carrying the connections through both tappers in the manner shown in 19 is to prevent the short-circuiting of the battery by the simultaneous depression of both tappers.

Conventionalisms. Figures 20 and 21 give the opportunity to mention one or two conventional rules. It may be noted that the battery is connected so as to have the zinc or negative pole at the left side and the copper, or positive pole, at the right side. This practice is invariable in the telegraphic world, and may be fixed in the mind by using as a mnemonic the word Z IN C. The circles represent battery terminals, and the mnemonic may be extended

to include the direction in which the voltaic current flows by noting that the direction is from Z to C (IN) the cell.

In 21 it will be noted that the top of the needle has moved in the same direction as the current. All needle and galvanometer instruments are made to conform to this. A third convention is the use of the terms "up" and "down." Since between two stations there is only one line, the terms really apply to the stations. In England, London, or the station nearest London, is usually called the "up" station, and the other the "down." Once this has been decided, the line may be joined up without fear of confusion. At the up station it is called the "down" line, because it goes to a "down" station, while at the "down" station it is an "up" line.

At an intermediate station there are, of course, two lines, and both titles are in evidence. The single-needle coils are wound to a resistance of 200 ohms, and require a working current of about 20 milliamperes. Small porous pot Leclanché cells are usually employed for the battery [see page 464]. For working a number of stations on one line the needle instrument has been found specially suitable, and it has been extensively used for this purpose on railway lines. Instead, however, of the tapper commutator, a form called the *drop handle* is used which is manipulated by one hand. The handle has three positions - namely, centre or normal, left and right, the two last producing deflections in the opposite directions. The arrangement is shown diagrammatically in 22. The handle, H, mounted on the axle, A, has two metallic parts, C and Z, insulated from each other. To C and Z are connected the poles of the battery, B. S and T are two strong springs which normally press against the bridge piece, P, and so maintain the continuity of the circuit. If, now, the handle is pushed to the right, C will press against S, forcing the latter away from P, and Z will make contact with T. As a result, a current flows viâ C, S, SN, up line, through distant apparatus, down line, T and Z. SN will, of course, deflect to the left, as will also the needles at all the stations on the line. On railway circuits there may be any number up to twenty.



25. DROP HANDLE DESK

On such lines the receiving instrument is usually of the Spagnoletti form [23 and 24]. The magnets are of horseshoe shape and the soft iron needle is made in two parts, one being the top and rear end of the axle, the other being the bottom half of the needle and the front end of the axle. These are united by brazing across a diagonal, the intervening layer of spelter keeping them magnetically separate. The broadening at the top and bottom of the needle results in firmer signals.

Fig. 25 is a view of a set from which the writing desk has been removed to exhibit the internal arrangements. One of the receiver coils has been unscrewed from its position between the horseshoe magnets and is balanced on the front of the case. The needle and its axle are thus exposed to view.

The Sounder System. This, the simplest and by far the most popular method of telegraphy came to us from America. It forms another instance of simplicity evolved from complexity.

Contemporaneously with the work of Wheatstone in England, Morse, in America, was working at an attempt to produce an automatic recording system. The receiving instrument was an electromagnet [see page 561] with its armature controlling an embossing needle, which marked a moving paper ribbon. At the sending end impulses were sent by contacts made under the control of a moving board with pins arranged at intervals. This was displaced by the now familiar key, when it was found that the signals could be very well made by hand, and the discovery that the signals of the electromagnets could be interpreted by the ear led to the simplification of the receiving instrument. A modern sounder circuit is equipped with a sounder, usually fixed in a sounder screen with a revolving turntable, a single-current key, a single-current galvanometer, and a battery [10, page 4606].

Continued

continued from page 4724

AREAS

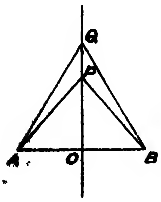
Examples on Loci. Methods of Finding Areas of Rectangles, Parallelograms, Triangles, and Other Rectilineal Figures

By HERBERT J. ALLPORT, M.A.

Proposition 29. Problem

To find the locus of a point which is equidistant from two given points.

Let A and B be the given points.



It is required to find the locus of a point P which moves so that PA is always equal to PB.

Since P moves through all positions in which PA = PB, it follows that one of its positions will be at O, the middle point of AB.

Let P be some other position of P, so that PA = PB. Join OP.

Then, in Δs POA, POB, the three sides of the one Δ are equal to the three sides of the other.

$\therefore$ they are equal in all respects (*Prop.* 7).

$\therefore \angle POA = \angle POB$.

Hence OP is $\perp$ to AB (*Def.* 8), *i.e., P lies on the line which bisects AB at right angles.*

Next, let Q be any other point which lies on the line bisecting AB at right $\angle$s. Join QA, QB. Then, it is easily shown that Δ QOA = ΔQOB in all respects (*Prop.* 4).

$\therefore$ QA = QB.

Hence, *every point on the line bisecting AB at right $\angle$s is equidistant from A and B.*

$\therefore$ this line is the required locus.

Intersection of Loci. The position of a point subject to two conditions may be found by using loci. For each condition gives a locus on which the point must lie, and therefore the point, or points, where the loci intersect will satisfy both conditions.

Example. *Find a point equidistant from three given points, A, B, C, which are not in the same straight line.*

Since the point is to be equidistant from A and B, it lies on the straight line bisecting AB at right $\angle$s (*Prop.* 29).

Since the point is to be equidistant from B and C it lies on the straight line bisecting BC at right $\angle$s.

$\therefore$ the intersection of these two lines is the point which is equidistant from A, B and C.

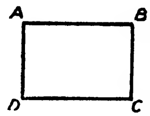
AREAS

Definitions. 1. *The altitude of a triangle,* with reference to one particular side as base, is the length of the perpendicular drawn to the base from the opposite angular point.

2. *The altitude of a parallelogram,* with reference to one particular side as base, is the length of the perpendicular drawn to the opposite side from any point in the base.

3. The *area* of a figure is the amount of surface enclosed by its bounding lines.

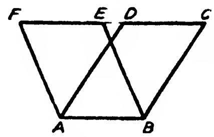
It has been shown in the course on Arithmetic, page 1442, that *if the number of units in the length of a rectangle is multiplied by the number of units in the breadth of the rectangle, the product gives the number of square units in the area of the rectangle.*



A rectangle ABCD is said to be *contained* by any pair of adjacent sides. Thus the rectangle is denoted by *rect. AB . AD,* or by *AB . AD* only.

Proposition 30. Theorem

Parallelograms on the same base and between the same parallels are equal in area.



Let ABCD and ABEF be two $\square$s on the same base AB and between the same $\|$s AB and FC.

It is required to prove that

area of $\square$ ABCD = area of $\square$ ABEF.

Proof.

FE = AB, since ABEF is a $\square$ (*Prop.* 23),

AB = DC, since ABCD is a $\square$.

$\therefore$ FE = DC.

$\therefore$ by adding ED to each of these equals, we have FD = EC.

Hence, in the Δs ADF, BCE,

FD = EC,

DA = CB (*Prop.* 23),

AF = BE (*Prop.* 23).

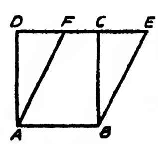
$\therefore$ ΔADF = ΔBCE (*Prop.* 7).

Now, if ΔADF is taken away from the whole figure, the remainder is the $\square$ ABCD. And, if ΔBCE be taken away from the whole figure, the remainder is the $\square$ ABEF.

But, since the Δs taken away are equal, the remainders must be equal.

$\therefore$ $\square$ ABCD = $\square$ ABEF.

NOTE. The $\square$s may be such that the sides FD and EC do not overlap, as in the figure. Or, the points D and E may coincide. In the first of these cases we can still show that FD = EC, and the proof is as given above. In the second case, when D and E coincide, the proof is still more simple, for it is obvious that each $\square$ is double of the ΔABD (*Prop.* 23).



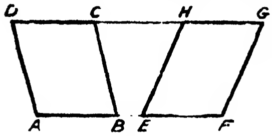
Area of a Parallelogram. By the last proposition, a rectangle ABCD and a $\square$ ABEF on the same base AB and between the same $\|$s are equal in area. But we have seen that the area of the rectangle is AB $\times$ BC.

$\therefore$ the area of the $\square$ is also AB $\times$ BC.

That is,

Area of a parallelogram = base $\times$ altitude.

Corollary. Parallelograms on equal bases and between the same parallels are equal in area.

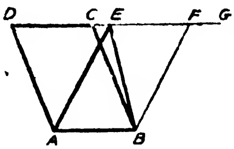


For, let the ▱s ABCD, EFGH have *equal* bases AB, EF. They also have equal altitudes because they are between the same parallels.

∴ area of ABCD = AB × altitude
= EF × altitude
= area of EFGH.

Proposition 31. Theorem

If a parallelogram and a triangle are on the same base and between the same parallels the area of the parallelogram is twice the area of the triangle.



Let the ▱ABCD and the △ABE be on the same base AB and between the same ∥s AB, DG.

It is required to prove that

Area of ▱ ABCD = 2 × area of △ABE.

Proof. Draw BF ∥ to AE to meet DG at F.

Then ABFE is a ▱.

And ▱ ABCD = ▱ ABFE (*Prop.* 30).

But ▱ABFE = 2 × △ABE, since the diagonal BE bisects the ▱.

∴ ▱ ABCD = 2 × △ABE.

Area of a Triangle. In the figure of Prop. 31, the ▱ ABCD and the △ ABE have the same altitude, *viz.*, the perpendicular distance between the ∥s AB, DG. But,

Area of ABCD = AB × altitude,

and it has been proved that ABCD is double of △ABE.

∴ △ABE = $\frac{1}{2}$ AB × altitude.

Thus,

Area of a triangle = $\frac{1}{2}$. *base* × *altitude*.

Corollary. Triangles on the same base and between the same parallels are equal in area.

For, the △s have the same altitude, and the area of each △ is $\frac{1}{2}$ base × altitude.

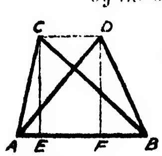
Similarly, *triangles on equal bases and between the same parallels are equal in area.*

Proposition 32. Theorem

If two triangles which are equal in area are on the same base, then

(i.) *If they lie on the same side of the base, the line joining their vertices is parallel to the base.*

(ii.) *If they lie on opposite sides of the base, the line joining their vertices is bisected by the base.*



Let ABC and ABD be two △s which are equal in area.

(i.) If the △s lie on the same side of the base AB, it is required to prove that CD is ∥ to AB.

Proof. Draw CE and DF ⊥ to AB.

Then △ABC is half AB . CE

and △ABD is half AB . DF.

But the △s are equal.

∴ AB . CE = AB . DF.

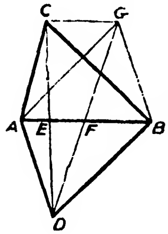
∴ CE = DF.

Now, CE and DF are ∥ (*Prop.* 11).

∴ since EFDC has two sides equal and parallel, it is a ▱ (*Prop.* 24).

∴ CD is ∥ to AB.

(ii.) Let △s ABC, ABD lie on opposite sides of AB, and let AB and CD cut at E.



It is required to prove that CE = DE.

Proof. Draw AG, BG ∥ respectively to DB, DA. Join DG, cutting AB at F, and join CG.

Then ADBG is a ▱.

∴ DF = FG (*Prop.* 23),

and

△AGB = △ADB (*Prop.* 23)
= △ACB (*Hyp.*).

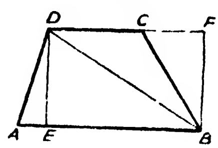
∴ GC is ∥ to AB (by i.).

Hence, in △DGC, a straight line FE is drawn through F, the middle point of one side, ∥ to a second side.

∴ it bisects the third side (*Prop.* 26).

∴ CD is bisected at E.

Area of a Trapezium. Let ABCD be a trapezium, in which AB is ∥ to CD. Draw DE ⊥ to AB, and BF ⊥ to DC. Then

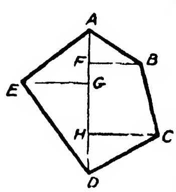


Area of ABCD
= △ABD + △DBC
= $\frac{1}{2}$. AB . DE + $\frac{1}{2}$CD . BF
= $\frac{1}{2}$ AB . DE + $\frac{1}{2}$ CD . DE
= $\frac{1}{2}$ DE(AB + CD).

That is,

Area of trapezium = $\frac{1}{2}$ (*sum of the parallel sides*) × *distance between them.*

Area of any Rectilineal Figure. A rectilineal figure can always be divided into right-angled triangles and right-angled trapeziums, and the area of the figure is obtained by adding the areas of these triangles and trapeziums.



Let ABCDE be any rectilineal figure. Join any two vertices, such as A and D. From the remaining angular points, B, C, E, draw perpendiculars BF, CH, EG, to AD. The figure is thus divided into four right-angled triangles and a trapezium whose areas are easily calculated. For example, suppose the measurements are those given in the annexed table, the various lengths being measured from A, along AD, to the points where the perpendiculars meet AD.

	From A.	
	AF = 2	FB = 3
GE = 4	AG = 3	
	AH = 6	HC = 4
	AD = 8	
	Inches	

Then, area of figure
= △AED + △AFB + △CHD + fig. BFHC
= $\frac{1}{2}$. AD . GE + $\frac{1}{2}$. AF . FB + $\frac{1}{2}$. CH . HD + $\frac{1}{2}$. FH (FB + HC)
= $\frac{1}{2}$. 8 . 4 + $\frac{1}{2}$. 2 . 3 + $\frac{1}{2}$. 4 . 2 + $\frac{1}{2}$. 4 . 7.
= 16 + 3 + 4 + 14
= 37 square inches.

Continued

THE MAKING OF BESSEMER STEEL

Group 14
METALS
8

Continued from page 4750

The Theory of Bessemer Steel Production. The Bessemer Converter and its Operation. Modifications of Bessemer's Process

By A. H. HIORNS

IN the Bessemer steel process—forcing air through molten pig iron in numerous small jets—the silicon and carbon become rapidly oxidised, and produce sufficient heat to maintain the iron in the liquid state until it is completely purified. Two different modes of working are adopted, according to the nature of the pig iron and of the lining of the vessel. These are termed the *acid* and *basis* processes respectively. Sir Henry Bessemer's great invention is not confined to blowing air through molten pig iron, but includes numerous mechanical appliances invented by him for carrying out the process, as well as the shape and construction of the converter. The original vessel was fixed with air inlets at the side, but this was soon replaced by a tipping converter, supported on trunnions, the air being injected at the bottom. After trying various patterns, he adopted the pear-shaped vessel now commonly employed. The inventor perceived the great advantage of conserving the great heat of the ingots by covering them, when stripped, with hot sand, from which the still red-hot ingots were carried to the rolls. This was the first crude idea of soaking-pits, afterwards so successfully applied by Gjers.

Acid Process. In the acid process, the iron employed is a grey hæmatite pig, rich in silicon and very low in phosphorus. It is generally melted in a cupola and run into the converter when in the horizontal position. The blast is turned on and the vessel rotated into the vertical position. In the first stage the graphite is changed into combined carbon, and silicon is oxidised, forming a slag with oxides of iron and manganese. In the second stage the carbon is oxidised to carbonic oxide, the evolution of which causes a violent action, with the ejection of showers of sparks and a brilliant flame. As soon as the carbon is removed the flame drops and the blow is stopped. About 10 per cent. of spiegeleisen or its equivalent of ferro-manganese is then added, and imparts the necessary carbon, the manganese taking up the oxygen from the iron, thereby forming oxide of manganese, which passes into the slag.

The length of the blow depends on the quality of the pig iron, and chiefly on the silicon and manganese content. It varies in duration from 15 to 30 minutes. The loss of iron in the process varies from 15 to 20 per cent.

The steel is poured into the casting ladle, which rests on the jib of a ladle crane. This crane now swings the ladle successfully over the ingot moulds standing in the casting ring, and the steel is run into the moulds through a nozzle in the bottom of the ladle by raising the internal stopper by means of a lever on the outside.

The ingot moulds are lifted from the partly-solidified ingots by the ingot cranes and by means of tongs, termed *dogs*, hanging from these cranes. The ingots themselves are lifted and carried to the heating furnace in the rolling department.

After discharging the steel, the converter is inverted to tip out the slag, and repaired, if necessary, before running in another charge. The oxide of iron produced by the blast on the ends of the twyers gradually corrodes them, so that the twyers become gradually shorter and the bottom thinner. After 15 to 20 heats the bottom is removed and renewed.

Limitations of the Acid Process. It has already been stated that the acid process is applicable only for pig iron low in phosphorus, but sufficient silicon must be present to yield the necessary heat. The varieties of iron used in this country are those smelted from hæmatite or magnetic ores. Since the purification of the crude metal is effected by the oxygen of the air, it is obvious that the greater fluidity of grey iron is advantageous, as the plastic condition of molten white iron is liable to interfere with the passage of the air through the molten metal. In fact, white iron can be treated only with increased waste, especially as it is deficient in silicon. Moreover, white iron is often much higher in sulphur than grey iron. Also, the carbon being in the combined form, the production of carbonic oxide takes place at too early a stage of the process, and afterwards, the carbonic oxide being present in insufficient quantity, the requisite high temperature is not attained.

The chief essentials, then, in the composition of the pig are a very low percentage of sulphur and phosphorus, with about 2 per cent. of silicon. Both silicon and manganese can be practically removed by the blow, as both elements are oxidised and unite to form a slag. The following analyses give the composition of some Bessemer pigs.

	Carbon.	Silicon.	Manganese.	Phosphorus.	Sulphur.
Charcoal pig	3·90	1·96	3·06	0·04	0·02
Greenwood	3·75	1·76	0·13	0·08	0·14
Snelus ..	3·27	1·95	0·09	0·05	0·14
Staffordshire	3·94	1·61	0·12	0·02	0·03
Jordan ..	4·40	1·81	1·08	0·01	0·04
American ..	3·10	0·98	0·40	0·10	0·06

Howe stated in 1890 that while there are American mills where 2 per cent. or more of silicon is present in the charge, the majority use less than 1·75 per cent., and what appears to be the most characteristically American practice has habitually only 0·66 per cent. to 0·9 per cent. of silicon. In order to blow iron with such little silicon successfully, the heats must follow each

other quickly, and the vessels and ladles must be very hot. He considers that as far as convenience of blowing is concerned, 1·25 per cent. of silicon is the best proportion. Metal with 0·5 per cent. of silicon has been blown in Sweden, but this is done only when the initial temperature is very high. For low silicon, then, quick blowing and short intervals are necessary.

Results of the Acid Process. In the acid process almost all the effective heat comes from the combustion of the silicon, and the greater the percentage of silicon the hotter the charge, the longer the blow, the greater the loss, the more expensive the repairs and maintenance, and, with high silicon, the poorer is the quality of the steel likely to be. If, however, the silicon is too low, it causes cold heats, heavy sculls, and bad working generally. The place of silicon may be taken to some extent by manganese, as in Styria and Sweden, where the cast iron is obtained from spathic ores. In such a case the silica lining is called upon to supply the silica for forming a slag with the oxide of manganese. If the blow be too hot, as indicated by the appearance of the flame, scrap steel is added to lower the temperature. In England, where high silicon irons are used, the aim is to keep the silicon sufficiently low, while in Sweden it is just the reverse. With coke pig, when the silicon is low, the sulphur will probably be too high, causing red-shortness in the steel.

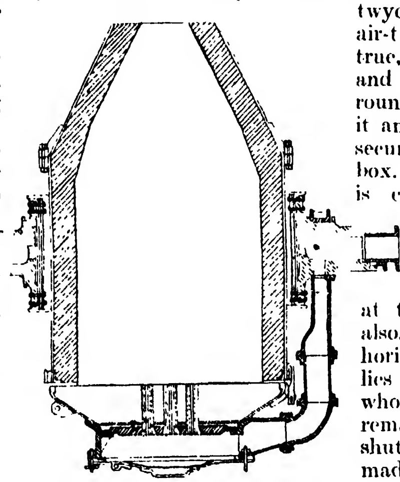
When the amount of manganese in Bessemer pig iron is upwards of 2 per cent., as it often is in Sweden, the direct method is adopted—that is, the blow is not continued till the whole of the carbon is burnt off, as in England, but stopped when the metal contains the desired amount of carbon, which is judged by the aid of the spectroscope and the colour of the slag. The amount of manganese left in the steel varies from 0·1 per cent to 0·3 per cent.

The gases escaping at the mouth of the converter indicate that at the beginning of the blow the carbon is largely burnt to carbon dioxide. At the end of the blow the gas given off is chiefly nitrogen.

The Converter. The modern converter is built of mild steel or wrought-iron plates riveted together and lined with siliceous or basic material, according as the acid or basic method of working is adopted. We may broadly classify Bessemer converters into *fixed* and *movable*. The former have only a limited application, but the latter are the kind generally employed.

The acid-lined converter is lined internally with silica bricks or with ganister, which may be rammed round a central core. The vessel is supported on trunnions, one of which is hollow and connected with the blast main, through which the air from the blowing engines passes to the wind-box at the bottom of the converter. The body is mounted on an iron ring, to which it and the trunnions are bolted. In the early vessels the entire shell was riveted together, but in the modern vessel the bottom and the nose are detachable from the body. The importance of a movable body will be perceived when it is mentioned that the twyer portion lasts only from 15 to 20 heats, while the body will stand several months' wear. The nose is not often removed except for relining. The centre of the bottom section is the *plug*, in which are fixed the fireclay twyers, each containing 12 to 18 holes, about ⅜ in. in diameter, through which the air passes to the metal.

The entire bottom is fixed to the body by means of lugs and cottar-pins, and is made easily removable for the examination of faulty twyers, but it must also be air-tight. Hence it is faced true, with a wide bearing, yarn and clay packing being put round the bottom plate between it and the box, the plate being secured by cottars to the blast box. The movable converter is capable of rotation in a vertical plane through an angle of 180° or more, thus enabling the contents to be discharged at the end of the blow; and also, by turning it into a horizontal position, the metal lies out of the blast below the whole of the twyers, and may remain there after the blast is shut off. The converter is made in two forms, known as the concentric and the eccentric forms. The former is shown in **37** and the latter in **38**.



37. CONCENTRIC CONVERTER

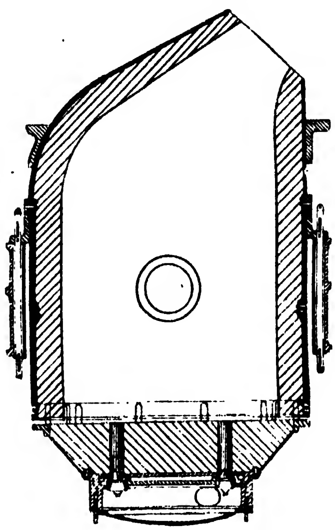
Rotating Mechanism. For the rotation, an iron framework supported on columns carries the converter on suitable bearings, arranged so that the vessel can be rotated on its trunnions. This is effected by means of a pinion, keyed on to one of the trunnions, gearing into a rack attached to the end of a double hydraulic ram. The position of the ram and cylinder may be either vertical or horizontal. Both the rack and pinion and the ram must be securely cased in sheet iron, to prevent injury by splashing of the metal or the slag on them. The valves for the hydraulic cylinder are usually controlled at some distance from the converter from a raised platform known as the *pulpit*. In some cases the rotation is effected by a worm and pinion gear, actuated by a hydraulic engine or by a double or triple cylinder steam-engine. In addition to other advantages, this allows for a complete revolution of the vessel through 360°. However, the simplicity of the rack and pinion arrangement, and the facility with which it may be manipulated, have led to its general adoption.

The bottom of the converter being the portion subjected to the greatest wear, and requiring

to be frequently removed, is made interchangeable, and a number of bottoms are kept in readiness, so that when one gives way it can at once be replaced. This is done by placing a trolley on the table of a hydraulic ram, fixed under each converter, and then, having raised the trolley and uncottered the bottom section, the latter is removed by means of the ram. In fixing a new bottom, it is run on a carriage to the table of the ram, wet ganister and fireclay is placed round the bottom section, and the bottom pressed tightly against the bottom of the converter by the hydraulic ram, and cottered on. In some works, instead of using a hydraulic ram under the converter, the bottom is hoisted into position and pressed home by powerful screw-jacks.

The lining of the Bessemer converter in this country is a siliceous sandstone. which contains from 85 to 90 per cent. of silica, and occurs below the coal measures. This is ground fine, mixed with water, and rammed in between a central wooden core and the shell of the vessel. In America the lining consists of a mixture of 60 per cent. crushed quartz, 25 per cent. fireclay, and the remainder of ground-up firebricks and other siliceous material. The American lining lasts for 400 to 500 heats. while the British lasts double that time; but we must take into account the more rapid working of the American vessels.

Concentric Vessel. In the eccentric vessel [38] a large amount of metal can lie in the belly without running into the twyers or out of the nose, and to some extent it prevents slopping. When the method of using metal direct from the blast furnace was introduced, a modification of the converter appeared necessary, so that it might receive molten pig iron from the blast furnace ladle when turned away from the pit. and receive spiegeleisen from the cupola when turned towards the pit. This is readily done with the concentric, but not with the eccentric vessel. The concentric vessel is, however, required to be larger than the eccentric, in order that when turned down it may hold a given charge on each side without running out at the mouth or into the twyers. The ratio of the capacity of the concentric vessel to the eccentric vessel is as 3·5 to 5, but in consequence of the greater size, less slopping occurs, and much of the metal ejected during the boil falls back into the vessel. Now, the path over which the metal runs to the converter is very highly heated, and the slag afterwards formed more easily corrodes this more highly heated portion; hence the advantage of equalising this wear by pouring alternately into each side of the vessel. The concentric converter is generally made in four parts, connected by bolts and cotters for easy detachment.



38. STEEL ECCENTRIC CONVERTER

A 10-ton converter weighs about 40 tons; the steel or wrought iron plates are 1 in. thick. with 1 in. rivets and strong straps; the four parts are connected by pins and cotters. The belt and trunnions are in two pieces, formed of cast-iron box sections; the trunnions are 21 in. long. The belt weighs 11 tons, and is 10 ft. 8 in. in internal diameter. The tipping gear may consist of a worm-wheel 8 ft. in diameter, gearing into a screw of $4\frac{1}{2}$ in. pitch, which receives its motion directly from the cranks of a pair of hydraulic engines mounted on one of the converter's standards. This allows of the vessel being turned over in either direction. A rack and pinion arrangement for tipping is much more common. A large converter of this kind for 15 ton charges is $24\frac{1}{2}$ ft. high, and mounted on piers 20 ft. above the ground Such a vessel may weigh from 60 tons to 70 tons A wide nose may be advantageous from the point of view of reducing loss from ejected metal; but the narrower the nose the higher the possible working temperature, and the greater the amount of metal the vessel can hold in the horizontal position.

Cupola Furnace. The molten metal for supplying the converter may be melted in a cupola, or taken direct from the blast furnace, or from the latter to a receiver or mixer before finally passing to the converter.

The modern cupola is really a small blast furnace. In some cases the outside shell will be 10 ft. to 12 ft. in diameter, and the blast pressure as much as 2 lb. t 3 lb. per square inch. It is lined with a firebrick as a backing, and then rammed, usually with ganister or some other siliceous material. The height of the cupola platform should be such that when the cupola is *dumped*, or raked out, all the débris falls upon the floor level, and ample room should be left to enable the men to remove this easily. Cupolas with drop bottoms are now generally made, and found very convenient. A moderate sized cupola has an exterior diameter of about 6 ft. to 7 ft., with five or six twyers, and is worked with a blast pressure of 1 to $1\frac{1}{2}$ lb. It will melt 200 to 300 tons of pig iron per 12 hours.

The position of the cupola is generally such that the metal can flow by gravity from the taphole to the Bessemer vessel, hence it is placed at a higher level. If the cupolas are too near the converter, the workmen are exposed to excessive heat, being between two great fires. On the other hand, if the cupolas are too far away, the long runners tend to chill the metal too much, and some of it will solidify, causing much waste. In some works this difficulty has been overcome by using travelling iron ladles to convey the iron from the cupola to the converter, either by running on a track or by means of a crane,

which admits of the tipping of the molten contents of a ladle into the converter.

Tipping ladles are now frequently used to convey cast iron from the cupola, or mixer, to the Bessemer converters. The ladle is held in a cast-iron trunnion belt by means of bolts and snugs. The tipping action is effected by a worm and screw motion actuating a trunnion, so that the workman can easily pour a charge of 20 tons of iron. The ladle is lined with firebricks with taper sides and fitting into one another. When these are built in, the whole is covered with a fireclay daubing. Another arrangement for tipping is by means of a chain fixed to the bottom and attached to a hydraulic cylinder, while the ladle is supported in the bearing of the carriage. The trunnions are not fixed centrally on the ladle, but somewhat in front, so that the whole metal can be poured into the converter by tilting without moving the ladle forward.

Ingot Moulds. The material from the ladle is teemed into cast-iron ingot moulds of various forms and sizes—square, circular, oval, octagonal, etc., open at both ends. They are made to taper considerably, being larger at the bottom than at the top, so as to allow for easy stripping. The usual method is to fill each mould separately, but the method of casting in groups is also used. A large ingot may be 19½ in. square, and weigh 50 cwt. For rails, the ingot is 14½ in. square, and weighs 25 to 30 cwt. Several smaller sizes are also used. The moulds are generally arranged in a shallow pit in a semicircle, so that the ladle crane may bring the nozzle of the ladle over each one in succession.

Sometimes, when an ingot is tapped, it is stoppered down by throwing some sand on it, and then covered with an iron plate, which is fastened down by a cross-bar and wedges. In group moulds they are generally arranged round a central one, somewhat taller than the rest, into which the metal is run, and whence it passes from the bottom to the bottoms of the others by means of fireclay tubes or passages. Hence the material rises in the moulds from the bottom to the top. A plan now largely adopted, especially in American works, is to have the ladle stationary, and a bogie truck carrying two moulds is run under the nozzle of the ladle for teeming. The bogie then conveys them away, and another pair is brought under the taphole, and so on in succession.

Basic Bessemer Process. This process is conducted in an ordinary converter, but a phosphoric pig iron may be used. Such an iron may contain 3 per cent. of carbon, 0·5 to 1 per cent. of silicon, 0·2 per cent. of sulphur, 1 to 2 per cent. of manganese, and 2 to 3 per cent. of phosphorus. In consequence of the basic lining, the slag is basic, and is capable of taking up phosphorus oxide. All acid substances tend to neutralise the base, so that only a certain quantity of acid material can be taken up. If, therefore, much silica be present, it will unite with the base in preference to the phosphorus oxide, which will be reduced and pass into the iron. To prevent this, excess of lime is necessary; but this raises the fusion point of the slag, and increases its quantity, so that a larger vessel is necessary. This means an addition to the cost, and an increase in the working expenses.

Now, grey pig iron generally contains much silicon, which renders it unsuitable for the basic process. White iron contains only a moderate amount of silicon, and is often high in phosphorus, which, being a good heat producer, and playing a similar part to that of silicon in the acid process, is required in the basic process. Another point of importance is the amount of phosphoric acid in the slag, whose value as a manure depends on its phosphorus content. Moreover, the purity of the lime is important, as impure lime may contain silica, and 1 lb. of silica requires 4 lb. of lime to neutralise it. Silica in lime generally amounts to about 2 per cent., and often more. In consequence of the lower temperature produced by the presence of lime, and the affinity of silica for such a strong base, the silicon is more thoroughly removed than in the acid process. Manganese is not, however, so completely removed. A highly basic slag is also favourable for the removal of sulphur, which takes place almost entirely during the after-blow.

Behaviour of Phosphorus. Phosphorus is not appreciably removed until most of the other elements have been eliminated and the heat of its oxidation is concentrated towards the end of the blow, when it is most required. Phosphorus is oxidised at the beginning of the blow; but, in the absence of a basic fluid slag rich in lime, the oxide is decomposed by the carburised iron at the high temperature prevailing in the converter. Towards the close the slag is highly basic, and then the oxidised phosphorus passes into the slag. On the addition of spiegeleisen or ferro-manganese at the end of the blow, some of the phosphorus is reduced from the slag and passes into the steel, probably due to the reducing action of the manganese.

At the end of the blow the iron is left in an oxygenated state to a greater extent than in the acid process, so that larger quantities of manganese compounds are required. To reduce the amount of oxide before adding the manganese compound, grey hematite pig iron is generally added, but the best method of preventing over-oxidation is to use good manganiferous pig iron.

The Basic Blow. The different stages of the basic blow are similiar to those described in the acid process, but during the boil larger quantities of slag are ejected. When the flame stops, instead of turning the vessel down and stopping the blast, as in the acid process, blowing is continued for three of four minutes longer. This is termed the *after-blow*, and during this period practically all the phosphorus is removed. The plant used in the basic process differs but little from that in the acid process, except that the concentric form of converter is more often used. The essential difference is in the lining, which must be strongly basic and sufficiently refractory to withstand the very high temperature to which it is subjected without melting or softening. The materials generally applied for the purpose are lime and burnt dolomite, mixed

with some cementing material, such as anhydrous tar.

Dolomite, or magnesium limestone, of high quality, and containing not more than 2 per cent. of silica, is desirable. It is first broken up into small lumps, and strongly calcined in a basic-lined cupola to remove moisture and carbon dioxide. The effect of this calcination is to produce a considerable shrinkage, and it is advisable to employ the shrunk material for lining the converter as soon as possible, otherwise it will absorb moisture from the air and rapidly deteriorate. It is next ground in a pug-mill and mixed with the desired amount of well-boiled tar. The prepared material is made into bricks of different sizes and shapes to suit the sweep of the converter. They are placed into position as soon as they come from the press.

Use of Small Converters. Although the general tendency has been to increase the capacity of the converters and the general adoption of bottom blowing, the small converter with side blowing is still used. These converters may be classified into *fixed, rotating, side blowing,* and *bottom blowing.*

Fixed Vessels. These converters have four chief defects: (1) They scarcely permit of bottom blowing, and therefore involve a great loss of iron in blowing. In bottom blowing the failure of a single twyer would let the whole charge escape. If a twyer in a rotating vessel fail, the vessel can easily be turned so as to bring the twyer above the level of the metal, when the faulty one can be repaired. This is a common occurrence. (2) Even in side blowing the failure of a twyer is a serious thing in a fixed vessel, because it is necessary to remove the charge at once, converting it into scrap. (3) At the end of the blow the charge has to be tapped out instead of being poured. Moreover, the proportion of carbon is less under control in the fixed vessel because of the length of time required to tap. (4) It is impossible to recarburise in the vessel, and this has to be done in the ladle. This is not important in mild steel, but in rail steel it is a serious thing. The fixed vessel is much cheaper than the rotating one, and in small works where the charges are small the low cost more than counterbalances the losses enumerated above.

Side Blowing. This may be near the bottom, as in the old Swedish converters, or higher up, as in the modern vessels. Side blast requires less blast pressure and therefore less cost in blowing engines, boilers, etc. The system has three chief disadvantages:

1. The action of the blast is not uniform through the metal, and the metal contains less carbon above than below the twyers, and although the portions may mix in the ladle, the metal is liable to be non-homogeneous.

2. The metal round where the blast enters is highly oxidised, while in bottom blowing the bath is so highly agitated that any oxidised portions are rapidly deoxidised by the carbon and silicon of the other part. Again, at the end of the blow the iron oxide escapes as a dense reddish-brown smoke along with the blast, and the metal is overblown. This imperfect mixing of iron oxide and the carbonated and silicated portions, in the case of side blowing, causes overblowing and consequent loss of iron.

In the old Swedish vessel the twyers were placed not radially, but in a tangential direction, so as to give to the metal a rotatory motion. The same is done in the Robert converter, which has also a vertical rotation by the twyer being on one side only.

3. The bottom and the sides near the twyers wear away more rapidly, causing the depth of metal to diminish, so that the blowing becomes more localised. In bottom blowing the depth of metal above the twyers changes but slightly, the corrosion being chiefly on the bottom. Side blowing has two advantages. It lessens the blast pressure, and prolongs the life of the twyers.

Clapp and Griffiths Converter. In this vessel the twyers were raised to about 10 in. above the bottom, so that when half the metal was tapped out the twyers were not out of the metal. The vessel is about 10 ft. high, 5½ ft. internal diameter, lined with silica bricks, and provided with four to six horizontal twyers, filled with valves for regulating the blast. As the slag rises it is run off through a slag-hole during the intermediate stages of the blow. At the conclusion the metal is tapped out the same as from a cupola. Ferro-manganese is added to the metal in the ladle. This process appears to eliminate the silicon, but leaves the phosphorus and sulphur practically untouched.

Hatton improved this form of converter by replacing the solid bottom with a movable one, and by introducing a simpler form of valve to regulate the blast. The movable bottom greatly facilitates repairs. The pig iron used must be practically free from phosphorus and sulphur, and contain 2 per cent. to 2·75 per cent. of silicon, otherwise the blow is too cold.

The Robert Converter. This, although a movable converter, is adapted only for small charges of from 1 to 3 tons. The blast is introduced near the upper surface of the metal, and the twyers inclined at different angles, so as to give a rotatory motion to the metal. The vessel itself is tilted during the first half of the blow, and turned more vertically as the operation proceeds, in order that the blast may be less strongly localised. The converter is mounted on trunnions and revolved in the usual way, but by means of hand gearing. The advantages claimed for this converter are several. No expensive blowing plant is required, the slag and gases separate better from the metal, a higher temperature is obtained, enabling castings to be made, the process can be stopped at any given moment, and steel can be made in varieties from the mildest to the hardest. The loss of metal in the Robert converter seems to be as great as in the fixed vessels, averaging about 20 per cent. The position of the twyers high up in the bath is a disadvantage, in that it leads to increased loss of metal by oxidation. The reduced pressure of the blast is an advantage.

Continued

THE LATHE

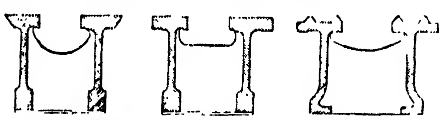
Invention and Development of the Lathe. Its Principal Details. Examples of Lathes. Special Types. Lathe Chucks

By FRED HORNER

ALL lathes, from the tiny watchmaker's to the great gun lathes, are constructed on the same principle—that of rotating the work, and presenting a tool suitably for cutting it. The immense variations in type and size are brought about by the necessities of special classes of work, the operations on which include turning, facing, boring, drilling, screw-cutting, knurling, milling, etc. The number of lathes in an engineering works usually exceeds that of any other single type of machine tool, the reason being that shafts, pulleys, wheels, bolts, pins, screws, and other cylindrical parts form a preponderating element in mechanisms, and all are done in the lathe. In woodwork also a large proportion is turned, but the lathes for woodwork are much lighter and simpler in construction than those for metal.

The essential difference between the smallest and the largest lathes is only one of power and convenience. Sufficient strength of parts and driving power must be provided, and means for gripping the work and presenting tools to it. The last-named provision often includes arrangements for using several tools, either successively or simultaneously.

The Early Lathes. The original form in which the lathe was constructed and is still used in



1 2 3

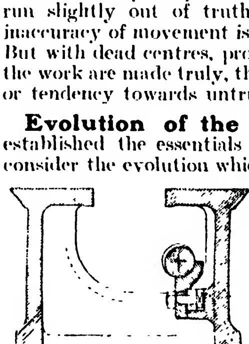
SECTIONAL SHAPES OF LATHE BEDS

Oriental countries comprises a bar carrying two blocks fitted with pointed centres, which enter into the ends of the work and afford it a bearing while rotating. A cord is wrapped round the work, and each end alternately pulled so that the work turns first in one direction, and then the other. The turner applies the tool while the piece is revolving towards him. As the lathe lies on the ground, either the hands or the feet of the turner are used to grasp the tool, leaving one hand free to operate the cord. But when a lad is employed to drive the cord, the workman has more freedom and scope. The results turned out of these most primitive lathes are astonishing; the principal drawback, of course, is that the speed is not high, nor are the revolutions continuous in one direction.

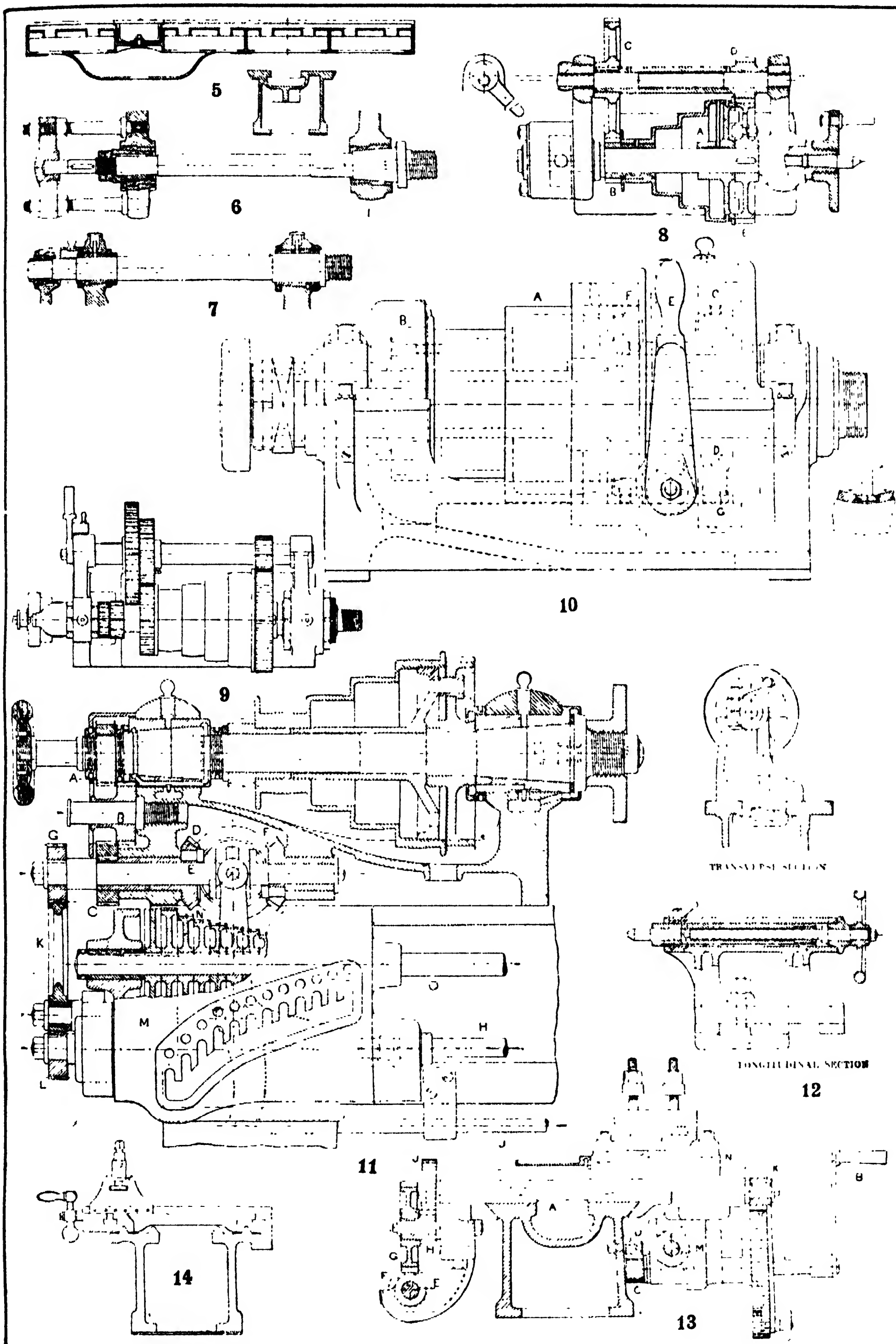
An improvement on this type was the *pole* lathe, in which the *bed* was raised up sufficiently to enable the turner to work while standing, and one end of the driving cord was attached to a long, springy pole overhead, while the other end was fastened to a foot-treadle below the lathe. Pressure on the treadle caused the cord to rotate the work in the cutting direction, while on release the spring pole pulled the cord upwards, ready for another downward motion. An alternative to the pole was an archery bow, which gave the requisite amount of elasticity. But these devices did not provide for continuous rotation in one direction. This was attained by the introduction of the *wheel-driven* lathe, in which a wheel revolving on an axle located either above or below the lathe drove an endless cord passing over the work, and turned it constantly towards the operator, enabling him to cut continuously without the annoying and time-wasting intermittent presentation of the tool. The only instance of the survival of the reciprocating lathe is that of watchmakers' *turns*—small lathes that have the piece driven between centres by a cord, the ends of which are attached to a bow, the latter being held in the hand and moved to and fro, winding and unwinding the cord on a pulley fastened on the work.

It will be noted that in all these cases the work is driven directly upon its periphery, and always runs between two points, which are called *dead centres*, because they do not revolve. The *running mandrel* lathe was a later development. Instead of driving directly on the surface of the work, a head was fitted up with a separate short *mandrel* or *spindle* and pulley to receive the cord, and the work was rotated by suitable *chucks* on the spindle *nose*. The advantages of this method were that the piece was unencumbered with driving tackle, only a small portion being occupied by the chuck, and that it could be gripped at one end only, leaving the other free to be hollowed or bored out into cup or ring forms, a class of operation that is impossible when the *back centre* is used. The germ of the majority of present-day lathes was thus established. All, with the exception of some special dead-centre types, have running mandrels, from which the work is driven or is gripped, the help of the back centre being employed in some cases, abolished in others. The reason for the retention of dead centres in certain cases is chiefly one of relative accuracy. There is always a possibility that a mandrel may run slightly out of truth, and in such case the inaccuracy of movement is reproduced on the work. But with dead centres, provided the centre holes in the work are made truly, there is no outside coercion or tendency towards untrue running.

Evolution of the Lathe. Having thus established the essentials of the lathe, we may consider the evolution which has taken place in the forms of the different parts. The *heads*, or *poppets*, were primarily constructed of wood—rough blocks fastened upon a bar of wood, the *bed*, which also supported the *tool rest* at a suitable height. Even the early running mandrels were of wood, which gradually gave place to iron, still revolving in wood bearings. Metal bushings were then inserted in the wooden heads, and, lastly, the heads were cast in metal. The bed underwent change, being made in two strips, or *shears*, set side by side a little distance apart. The



4. WHITWORTH LATHE BED

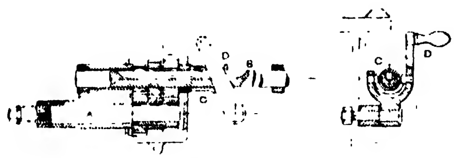


LATHE DETAILS

5. Sections through gap bed **6.** Solid mandrel **7.** Hollow mandrel **8.** Common back gear **9.** Back gear with two ratios **10.** Friction back gear **11.** Hendey-Norton nest change-gears **12.** Loose headstock or poppet **13.** Saddle with self-acting and screw-cutting motions **14.** Carriage with plain rest

heads had projections or checks on the bottom, which fitted between the shears, these checks being prolonged to the under side of the bed, and there secured with wedges, firmly holding the heads in place. Later, screw bolts performed the function. The space between the shears formed a slot, along which the tool-rest could be slid, and clamped at any desired point to operate on the work. The back poppet could also be moved nearer to or farther from the head to accommodate short or long pieces.

The limitations of the early lathes were those of capacity, because all the tools had to be held and controlled by the turner's hands, and heavy metal turning was difficult or impossible. With the invention by Maudslay of the *slide-rest* the possibilities of the lathe were at a bound immensely increased; tools were held rigidly against the stress of cutting, and moved along accurately in linear directions by the slides of the rest. The difficulties encountered in holding a *hand* tool up to rough or irregularly-shaped pieces disappeared, since the lumpy or eccentric portions on the surface could not push the tool away. Hand turning is still practised extensively in wood and in some classes of light metal work. It has little or no scope in an engineer's shop.



15. GEAR DRIVE WITH SLIDING KEY

With the increased strains involved, wooden beds had to give place to the more rigid ones of iron. At first the slide-rest was of limited range, depending on its length of slide, and it had to be shifted to a fresh position when a length beyond the travel was being turned. The next step, therefore, was to fit the rest to the bed in such a way that it could slide the entire available length, and so traverse along a piece of work completely. A *self-acting* motion next followed, by which the rest was fed automatically through connections from the *headstock,* screws being cut also by this means. Subsequently, a self-acting feed was given to the *cross* or *transverse* motion of the rest for *facing.*

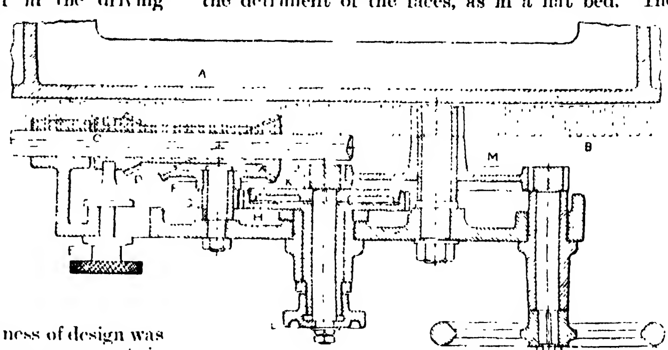
Improvements in the Driving Head.

Changes now began to appear in the driving heads. The *stepped cone* was introduced to give a range of speeds suitable to the size and character of the work being turned, the cord or belt being changed from a smaller to a larger step to gain greater driving power at a slower speed. The method was followed in both treadle and steam-driven lathes. Then as work increased in size, it was found impossible to get a cord or belt to drive the cut without slipping, and toothed gears were introduced to gain power at reduced speed. Compactness of design was obtained by the familiar *back-gear* arrangement, in which four toothed wheels drive from the mandrel pulley and back to the mandrel with an average ratio of 9 to 1. It is interesting to note that in some of the latest lathes for high-speed cutting, the belts have been eliminated altogether, chains or toothed wheels transmitting power positively from an electric motor to the lathe mandrel. The problem of getting a good range of mandrel speeds, formerly met by stepped belt cones and back gears of single, double, or treble types, has assumed greater importance since the introduction of high-speed steels, and developments are crowding fast.

Other points in lathe evolution include the practice of fitting more than one slide-rest, to enable a number of tools to operate on different portions of a piece of work, the inclusion of boring arrangements in place of the ordinary poppet, and improvements in screw-cutting devices. An advance that revolutionised some classes of lathe work was that of the *capstan* or *turret* fitting, which holds a number of tools radially in such a position that they can be brought into place in rapid succession to perform different classes of operations on a piece. These turret lathes reach the highest development in the *automatic screw machines* which carry through all their operations without the help of an attendant.

The *vertical* lathes, or *boring and turning mills,* are a class by themselves, and one of comparatively recent development. The axis of the spindle is set vertically, and the *table* or *face-plate* carries the work without the help of a back centre.

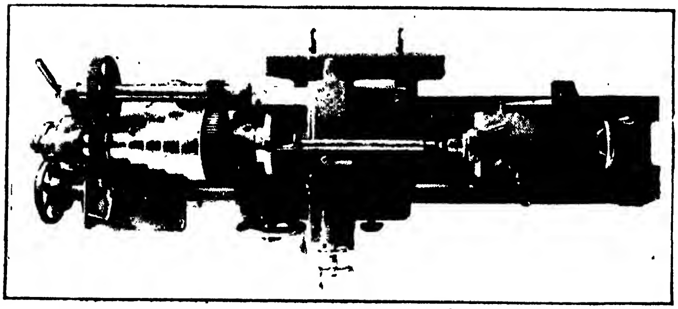
Beds. Studying now some of the principal elements of lathes, the basis of construction—the *bed*—comes first. The chief essential of a good bed is rigidity, so that there shall be no flexure or vibration under the stress of cutting. The early wooden beds did not provide against these evils, neither did they remain true. But previous to the introduction of cast-iron beds a little advantage was gained by attaching strips of iron to the wooden beds, to serve as guide-ways for the slide-rest. Some of these were flat plates, others were rounded or vee'd on the top, to guide the rest truly. The iron beds which followed also had very narrow top edges, sometimes flat, sometimes of vee shape, a practice which still survives in modern American lathes of small and medium size. In England, on the contrary, flat slides are preferred. The advantages claimed for the vees are that the *saddle* or *carriage* is guided truly without the help of the edges of the bed, because the vees automatically centre the carriage, just as a vee planer bed does its table; and the cuttings also fall off the sloping sides of the vees, instead of remaining on them, to the detriment of the faces, as in a flat bed. The



16. ARRANGEMENT OF APRON GEAR

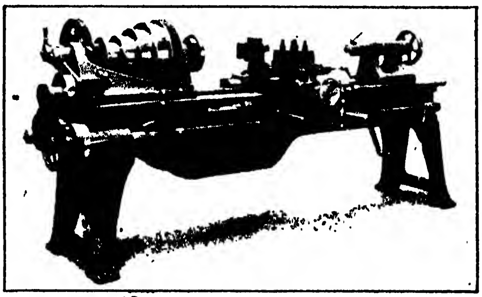
amount of bearing surface on vees is comparatively small, a defect partly compensated for by making the carriage base of great length. To keep the carriage down on its vees, a practice formerly much adopted was that of suspending a weight, which

hung down between the shears. This weight prevents the addition of strengthening cross-ties or girts being cast between the shears, and in any case is applicable only to small lathes. When the weight is discarded, *gibs*, or *setting-up* strips, are fitted to the edges of the bed so that the carriage cannot lift during cutting, and ample strength may be given to the bed by the use of cross-ribs at intervals. In the flat-top type of bed, the edges are usually vee'd, in order that one gib strip may serve two functions —prevention of both lifting and lateral motion. If square edges are employed, it is necessary to fit strips having both upward and lateral adjustments. A point of importance is that the use of vees reduces the available *swing*, or diameter that can be turned, by comparison with a similar lathe having a flat bed.



17. A 11-IN. SWING AMERICAN LATHE VIEWED FROM ABOVE

Two designs of recent date embody important variations on ordinary types. In the Lang bed, the saddle is not controlled by the extreme span of the bed, but only by a narrow guiding strip at the front, on which the saddle has a longitudinal bearing of about ten times the width. The risk of cross-working is greatly reduced, and the lead screw or feed-shaft is brought nearer to the guide portion. The Darling and Seller's "double-tier" bed has a supplementary ledge located some way down the front of the bed, the saddle having an extension resting on this. The effective width of the bearing is thus increased, and the weight of the front is better supported.



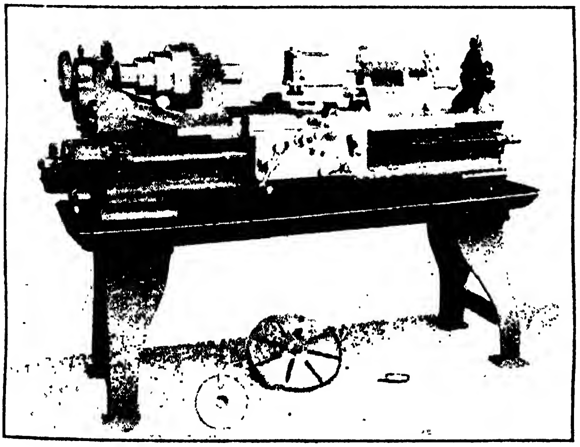
18. ENGLISH GAP LATHE
(Tangyes, Ltd., Birmingham)

In **1**, **2**, and **3**, the usual sectional shapes of the flat-topped beds, with vee and with square edges, and of the American vee tops are seen. The sectional forms are sometimes modified by the position of the *lead screw*. In the majority of cases it is placed in front, a little distance away, but in some designs a more central location is chosen, either about half-way up, and to one side, or close up under the ledge of the front shear. The pull on the carriage is more central and the screw is better protected. The Whitworth type of bed [**4**] has the screw set as shown, and supported on part of its circumference by bearings.

Some of the heavy lathes have beds with a greater number of bearing strips on the top, and in types where the entire saddle is not moved self-actingly tee-slots are cast to bolt the rests down by, and also racks to bar the rests into new positions.

Special sections of beds are the *front slide*, and the *triangular*. A style used for *bench* lathes forms a portion of a circle, the rest being flattened off to carry the heads and slide-rest. The front slide beds have their bearing surfaces upon the front, instead of the top, and the slide-rest travels without coming foul of the back poppet. The cuttings, moreover, fall off. But the chief advantage of the design is that it permits of fitting a *vertical slide*, a useful addition for milling.

The longitudinal forms of beds principally vary in being either *plain*, or *gap*. The latter breaks the continuity of the top by a space in front of the head, enabling wheels, etc., to be swung of larger diameter than the normal capacity over the top of the bed. The gap may or may not be filled in for ordinary use with a *bridge-piece*, over which the saddle passes. The weakening of the bed by the gap is compensated for by carrying ample metal down below. Fig. **5** illustrates longitudinal and cross-sections of a good type of bed, cast of "box" form, with lightening holes and circular wells for the cuttings to fall clear through. The bridge-piece is fitted in with shoulders, and is held with a bolt. The cross-sectional outline is shown enlarged beneath, taken at the position indicated by the dotted line.



19. TYPICAL AMERICAN LATHE

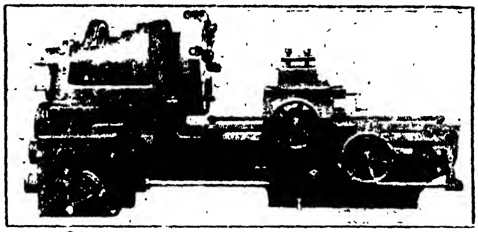
In the *movable gap* beds an opening of considerable width is obtained by fitting a supplementary or top bed on the main one, this upper bed being slid along to close or open out the width available for larger objects. Gap beds have always been more popular in England than in the United States. They are of great value in

general shops, because the range of a given lathe is not restricted, and it saves sending work having one part of large diameter to a lathe otherwise needlessly big for the job.

The mounting of a lathe bed which is not of sufficient depth to rest directly upon the ground is upon cast *legs*, the tallest of which are to be found in the small amateurs' treadle lathes. In this case, the standards serve as supports for the *crank axle*. The hollow box standard is increasing in favour for engineers' lathes; it is usually fitted with a door, and shelves are placed inside to carry tools, etc. Convenience is thereby studied, and a more rigid support afforded than that given by plain legs. A tray is often provided below the lathe bed to hold tools, or to catch lubricant and cuttings. A single standard is sufficient in some short-bed lathes, the top being formed into a tray. Standards in some instances take a three-point bearing on the ground, instead of the usual four, so that tendency to distortion through uneven foundations is obviated, the idea being borrowed from the familiar three-legged stool, which does not rock.

Headstocks. In the majority of cases, the headstock is a separate casting bolted down to the bed, but in certain special lathes the head and bed are cast in one piece, to gain solidity. Capstan lathes are the types principally so fitted. The ordinary headstocks consist of a base-plate, with which are cast two uprights, to serve as bearings for the mandrel at back and front. In a plain lathe there is nothing else but the mandrel and the pulley: when gears are introduced, alterations appear in the head casting. The fitting of a mandrel in its bearings is a most important matter, affecting the truth of the work produced, and there are a great many ways of attaining the object. Apart from easy running, means must be provided for taking up slack as wear occurs, and this should be done without having to dismantle the head. There are three methods in common employment. One is to make the *necks* of the mandrel coned, to be drawn into a tapered bearing, thus absorbing slack; another to have parallel necks, and run them in bushes, which are coned outside, to draw into coned holes in the head. The bushes, being split, contract upon the mandrel when moved endwise. The third method is to employ plain brasses, in halves, and closed down with a cap, held with set-screws.

In the best English practice, coned necks, running in hardened steel bushes, have been used for many years, and, provided they are properly hardened and fitted, no trouble is experienced. When badly made, however, difficulties occur through seizing of the steel surfaces. In America, bearings of softer metal have been favoured, such as cast iron, gun-metal, phosphor-bronze, Babbitt, and white metals. Practically all lathe-makers now employ these materials, especially the phosphor-bronze and the Babbitt.

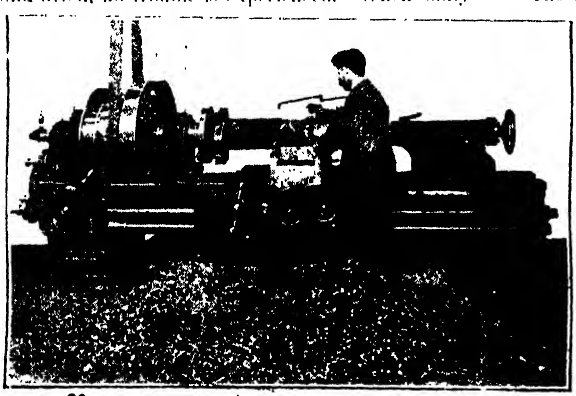


21. SURFACING AND BORING LATHE
(John Lang & Sons, Johnstone)

A question nearly as important as that of the necks relates to *end-thrust* when the lathe is working. In the more primitive lathes the mandrel has only a front bearing, and its back end is supported by a hardened point-centre, which receives the thrust, a construction still followed in many amateurs' lathes. But it is more satisfactory to have two bearings encircling the spindle. Then the thrust-pin must be placed beyond the rear bearing, being held by a couple of pillars and a bridge-piece. An alternative to the pointed centre is to have a plain pin, bearing on the flat end of the mandrel. Fig. **6** illustrates this, as well as the coned neck fitting just mentioned. The hinder cone is keyed on the mandrel, and forced up with nuts to maintain the running fit.

The objection to these end pins is that they do not permit of the convenient removal and replacement of the mandrel pinion, used for screw-cutting and turning, and they cannot be used at all with *hollow* spindles. Two ways are then available: plain thrust rings or collars of hardened steel or bronze may be used, or ball races, the latter being extensively employed now for light lathes. The thrust fitting is located at the front bearing or the back one, the latter being usual. In **7** the thrust is received in a casting at the extreme rear, with collars, an adjusting screw and lock nut making endlong alterations. The neck bearings of the spindle are of the coned-sleeve type, fitted with nuts at each end.

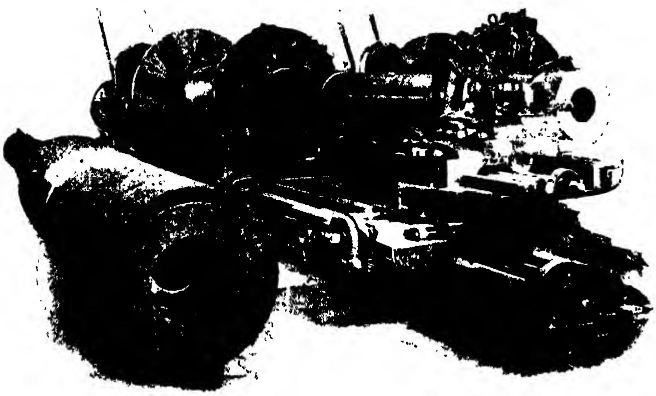
The fittings which go on the spindle include the chucks, the cone pulley, the first back-gear pinion, and the last wheel (or more if extra gear is included), the pinion for screw-cutting, and a belt pulley or pinion for feeding. The nose is coarsely threaded to receive the chucks, and there is a hole for the centre.



20. MASSIVE LATHE FOR HIGH-SPEED STEELS
(Dean, Smith & Grace, Ltd., Keighley)

Back Gear. As already mentioned, belt cones alone do not afford enough power for heavy cutting, a gain being therefore necessary by gears, termed *back gears*. The most common form of these is shown in **8**, a plan view of a head. It may be mentioned that the back-thrust device is similar to that in **7**. The belt drives the stepped cone, **A**, at various speeds, the cone running loose on the spindle, and carrying with it a toothed pinion, **B**. **B** drives a wheel, **C**, on a quill, with which is cast pinion **D**, driving the wheel **E**.

keyed on the mandrel. There is thus a double gain, which is usually designed to rotate the mandrel nine times slower than the belt pulley. But for light cutting, which the belt alone can tackle, connection



22. GUN LATHE WITHOUT POPPET (The Niles-Bement-Pond Co.)

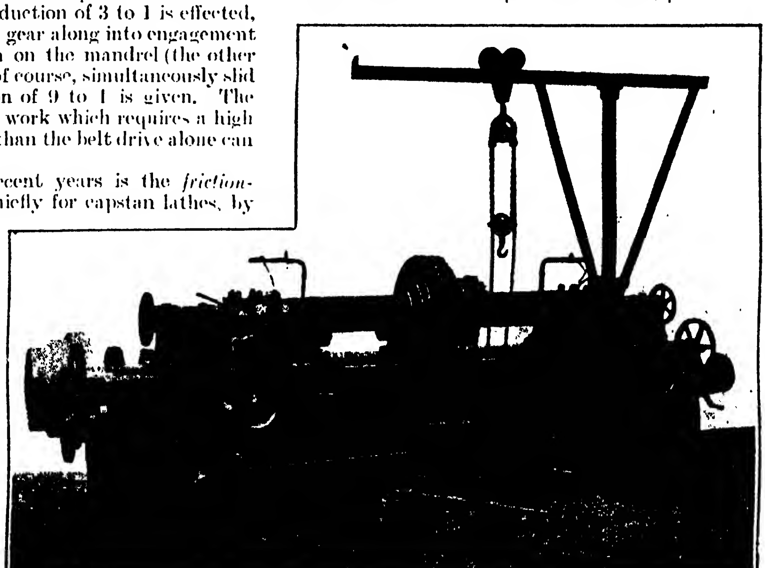
is made direct from A to E by sliding the bolt seen in E up the slot, and tightening it to engage with a stud cast on the disc of A, the latter then driving positively, while the gears, B, C, D, are out of action. They are put out by throwing C and D backwards, their spindle being keyed at each end in eccentric bushes resting in the extensions cast on the head. One eccentric bush is formed with a handle, seen in the end projection, by which the eccentric arc of rotation is given. The bush is sometimes locked with a pin to prevent the gears falling back, but by locating the eccentric in a certain way the pin may be dispensed with, as in the example shown. Formerly the back gears were slid endwise to disengage, but the eccentric throw-out is now preferred.

A design of back gear which gives the choice of two ratios is that in 9. There are two gears on the left-hand end of the eccentric quill. When set in the manner shown, a reduction of 3 to 1 is effected, but by sliding the larger gear along into engagement with the smaller pinion on the mandrel (the other gear on the quill being, of course, simultaneously slid out of mesh), a reduction of 9 to 1 is given. The 3 to 1 ratio is useful for work which requires a high speed, with more power than the belt drive alone can provide.

A development of recent years is the *friction-geared* head, adopted chiefly for capstan lathes, by which the operations of stopping the lathe and moving the locking bolt in the large mandrel gear are avoided, the change from direct belt drive to gear being made instantly by throwing over a lever.

Fig. 10 is an elevation of a friction-geared head of a capstan lathe by H. W. Ward & Co., Birmingham. The gears are enclosed under guards, but the resemblance to those in 8 will be apparent. The stepped cone, A, has its pinion, B, attached with screws and bushed with gun-metal; B drives a wheel on the back-gear shaft (not shown), and the pinion connected with this drives to spur wheel, C, running loosely on the mandrel, at a ratio of 4 to 1. A sleeve, D, is keyed fast on the mandrel between the spur wheel and the cone, A, and is extended into flanges that lie within A and C. Ring friction clutches are formed inside the flanges, as shown, and the expansion of the split rings produces sufficient friction within the cone or the wheel to drive. The action is effected by the handle, E, which has a pinion moving a rack on a sleeve sliding on D, so that the sleeve is slid to right or left. Recesses on the body coerce little toggle levers, F and G, which are pivoted to press down wedges between the halves of the friction rings, and so expand them. If the lever is moved to the left, therefore, the cone, A, drives the sleeve, and thence the mandrel; if to the right, the spur, C, drives the sleeve and mandrel, and the back gears therefore come into action. In the middle position of the lever the mandrel remains still. When the cone is driving direct the back gears may be thrown out by the usual eccentric, or left running if changes are frequent, as when turning and screwing alternate, requiring fast and slow speeds respectively. The spindle has a $2\frac{1}{8}$-in. hole right through for bars, and there are three protected set screws at the back to keep the bar central at that end, various chucks being fitted at the other end or *nose*.

As lathes get heavier, the ordinary back gear is insufficient to gain the power necessary, and extra trains are therefore introduced, *treble* or *quadruple*, with the option of using the direct belt drive or the ordinary double gear. The last pinion in such lathes drives on to a spur ring forming part of the



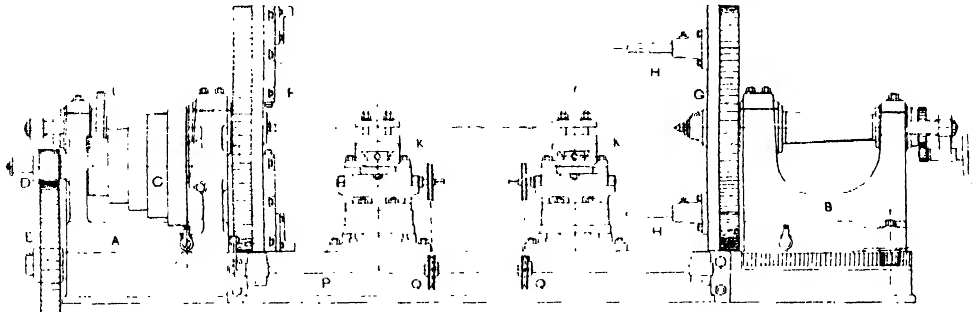
23. AXLE-TURNING LATHE (James Spencer & Co., Hollinwood)

face plate, so that the power is delivered at the most suitable location, and the spindle is relieved of a good deal of strain.

A considerable difference has been brought about in headstocks by the advent of high-speed steels, which are able to take greater cuts than the usual type of lathe can drive. The variations take the form of larger belt cones, increased gear gain, or the employment of all-gear heads, which derive their power from either a single belt pulley or an electric motor, all changes in speed and power being effected through sliding gears or keys.

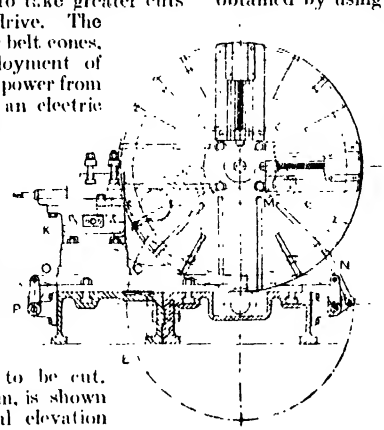
The screw-cutting arrangements of heads have been described on page 3628, and this is the usual type of fitting. A device which is now employed to a large extent on small and medium-sized lathes obviates the necessity of changing the gears from their studs whenever a different pitch of screw has to be cut. This, the Hendey-Norton system, is shown in **11**, which is a part sectional elevation through the head and end of the bed, containing the change mechanism. The pinion, A, on the tail of the spindle drives through an idler, B, which can be slid out of gear endwise. B drives C, mounted on a sleeve, at the end of which a bevel gear, D, drives the shaft, E, either direct, when the claw clutch seen is slid into engagement with D, or in the reverse direction, through the large bevel wheel, if the clutch is meshed with F. The shaft, E, then rotates pinion G on its end. The movements of the clutch are obtained through the rod, H, operating the curved pivoted lever seen dotted, H being extended through into the carriage, and there moved by the turner at any position without having to go to the headstock. The rod, J, is also extended to the carriage, and is struck by dogs, which have the effect of throwing the clutch mechanism just described out of gear, instantly arresting the travel of the tool, a useful provision when cutting up to shoulders.

The drive from G is through wheel, K, and pinion, L; the last-named rotates a shaft going inside the gear-box, M, and communicating to a larger wheel held in a pivoted frame. By this means the wheel may be moved along and thrown into mesh with any of the 12 gears, N, on the end of the lead screw, O, thus enabling 12 changes to be obtained without touching a gear. The slots and holes on the front of M are for locking the movable frame in each position by a handle and spring catch. The gears are so calculated as to give the regular set of threads from 6 to 20, others being obtainable by substituting a different gear for the one at L. Feeds are obtained by using the lead screw to actuate gears, by a spline down its length, and so to travel the carriage.

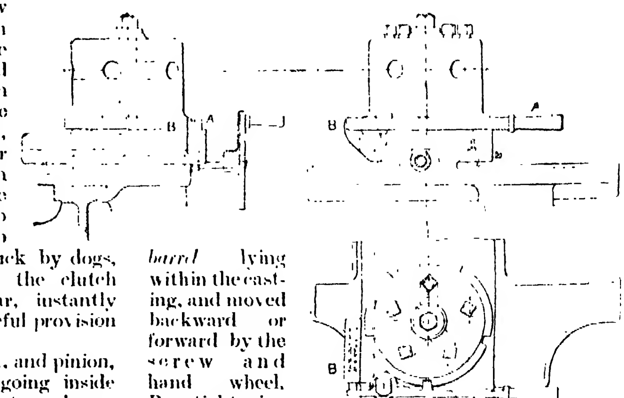


24. DOUBLE RAILWAY WHEEL LATHE

Poppets. The poppet, or loose headstock, is used in all lathes excepting those which do face work only, or turn long pieces with the help of guides combined with the tools. The two essentials in a poppet are means for moving and clamping the main casting, and then giving a short movement to the centre to force it up to the work. In **12**, it will be seen that the body is provided with tongues on the base, which fit between the shears and keep the poppet centre in alignment. Clamping is done by the bolt, which draws up the washer plate against the under side of the shears, and also, by means of the vee-fitting, pulls the poppet over to one side, which neutralises the effect of any slackness that may be present. The centre is fitted with a taper into a sliding *barrel* lying within the casting, and moved backward or forward by the screw and hand wheel. By tightening up the small handle seen, the barrel is locked by the action of closing in the split portion. The centre may be ejected by turning the hand wheel sufficiently far, causing the end of

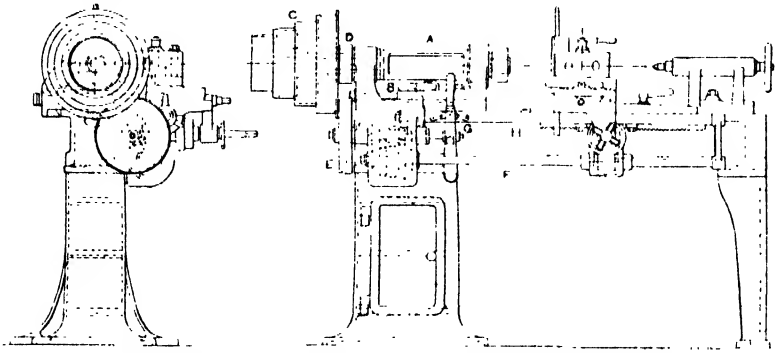


25. DOUBLE RAILWAY WHEEL LATHE
Transverse section



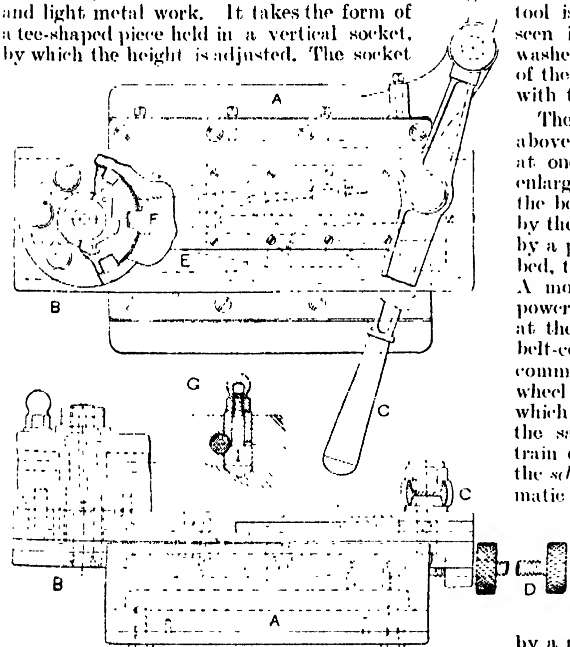
26. CIRCULAR CAPSTAN

the screw to press against the tail of the centre and push it out. On looking at the end view, it will be seen that the casting is cut away at the front, facing the turner; the object of this is to allow the handle of the top slide of the rest to clear when turning work with the poppet close up to the rest. The chief ways in which poppets vary from this example include *set-over* fittings and methods of operating the barrel screw. The set-over poppet is constructed with the upper part sliding across the base, clamped to the bed, by which means the centre can be thrown over to one side by a definite amount, enabling long objects to be turned tapering, instead of parallel, as when the centre is in alignment with the headstock. The setting is done with screws, and the clamping with set-screws or bolts. The heavier poppets are different in several respects from small ones; more holding-down bolts, four, or six in number, are used. The barrel is not moved out direct by a hand wheel at the end, but through intermediate gears, the wheel being brought to the front, near the nose, in order that the turner may have it conveniently close. Rack and pinion gear is also necessary to move the massive poppets along their beds.



27. OPEN-SPINDLE CAPSTAN LATHE (Webster & Bennett, Ltd.)

Rests. The *hand-rest* is used for wood-turning and light metal work. It takes the form of a tee-shaped piece held in a vertical socket, by which the height is adjusted. The socket



28. CAPSTAN FOR SHORT WORK

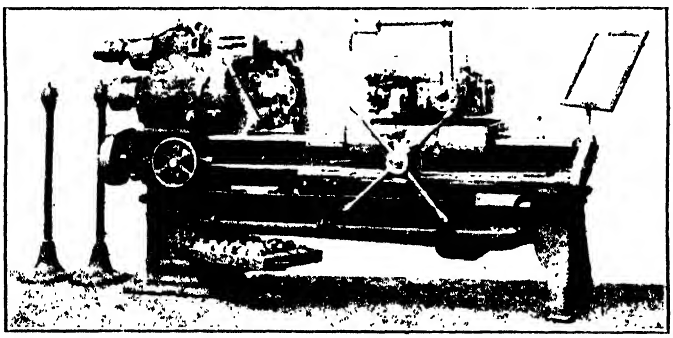
is clamped to the bed at any desired position. The rest does not control the tool, but simply supports it, the movements being effected by the turner.

The slide-rest in its simplest form consists of two slides superimposed, the top one travelling parallel to the axis of the lathe centres, the lower one at right angles or transversely thereto, constituting what is termed a *compound* rest. Tapered or bevelled parts are provided for by a swivelling movement, produced by the top slide turning on a circular face, bolts locking it thereto. Divisions around the edge indicate the amount of angling. The slides are moved along with screws, working in nuts fastened to the under sides of each slide. Clamping plates and studs on the top face of the upper slide hold the tools in place firmly. The usual method is to have four studs, with nuts, and two plates; another type has a block held on the rest with a central bolt, and the tool is held with a couple of screws passing through the open side of the block. In America, the single pillar *tool-post* is favoured, consisting of a slotted post, in which the tool is clamped with a set-screw from above, as seen in **14**. A convex strip lying in a concave washer is also usual; it allows of altering the height of the tool point by tilting, to bring it always level with the lathe axis.

The length of the slides of the rest described above limits the length of work which can be turned at one setting. In the *sliding* lathes, the rest is enlarged into a saddle or carriage, which slides along the bed from end to end within the limits imposed by the headstocks. The sliding motion is produced by a pinion gearing with a rack on the front of the bed, the pinion being rotated by a handle or wheel. A more regular movement may be imparted by power, as in the *self-acting sliding* lathes. A shaft at the back or the front of the bed is driven by belt-cones or gears from the headstock spindle, and communicates varying rates of motion to a worm-wheel on the saddle, through the medium of a worm which is free to slide over the splined *feed-shaft* as the saddle travels. The worm-wheel operates a train of spur gears ending in the rack pinion. In the *self-acting sliding* and *surfacing* lathes, an automatic surfacing or *cross-feed* is obtained by gears connected to the end of the cross-slide screw. The most complete lathes for *sliding, surfacing,* and *screw-cutting* have, in addition, a lead-screw driven by the change wheels at definite rates, the screw communicating longitudinal motion directly to the saddle by a nut, the *clasp-nut*, so called because it can be made to embrace the screw at will, either by forming it as a half-nut, pushed up or down to engage with the threads; or in two pieces, which are opened or closed upon the screw. A cam plate is the usual medium of operation, an example of which

is shown on page 828 [82]. The respective positions of the lead-screw and the feed-shaft were formerly at front and back respectively of the bed, hence the term *back-shaft*. The latter was driven by belt from cones on the headstock. An increasing practice, however, now is to put the feed-shaft in front below the lead-screw, which is a more compact arrangement, and admits of using a single set of change gears such as that in **11** for both screw and shaft. The shaft is frequently abolished altogether, the screw being splined to serve the double purpose, its feed worm sliding over the tops of the threads.

A saddle combining movements by lead-screw and back-shaft is shown in **13**. The saddle itself, A, is racked along the bed by the handle B rotating a pinion, C, gearing with the rack D. The self-acting sliding motion is derived from the back-shaft, E, rotating the worm, F, and wheel, G. The latter actuates a pinion, H, and thence a spur, J, on a shaft which runs right through the saddle, appearing on the front with a pinion, K, engaging with a wheel, L. The last runs loosely, but may be locked to a boss and disc keyed on the rack pinion shaft, by means of a wing-nut tightening a bolt in a slot running round L, so that the feed may be thrown in at any



29. LATHE WITH HEXAGON HOLLOW TURRET
(Alfred Herbert, Ltd., Coventry)

point of revolution. The teeth of the gears are usually covered with guards. The lead-screw with its clasp nut is seen at M. The upper slide, N, is fed across by handle and screw (not shown); it has a swivel facing, with bolts in a circular tee-slot, by which the top slide is held. This also has its screw, and the clamping plates. It may be noted here that the uppermost slide is not always fitted; a practice which is very common in the United States is to dispense with the last slide, and move the carriage bodily for feeding to or from the headstock. The form is then that in **14**, the transverse slide on the carriage carrying the tool-post. The carriage is seen to bear on two vees only, the central ones being reserved for the poppet to slide upon. The front portion or apron which hangs down in front is omitted in this view.

When the style of back-shaft in **13** is used for self-acting cross-feed, one of the spur wheels engages with a pinion running loosely on the end of the cross-feed screw, but made to drive the same, when desired, by means of a friction clutch, a device which is shown on page 961 [**111**].

When the feed-shaft is located in front of the bed the power is taken off by worm or bevel gears, and transmitted through spur gears to the rack and the cross-feed screw. These *apron gears* are arranged in a great many ways by different makers. Fig. **16** embodies the principal points which are found in the majority. The view is a section looking down upon the apron gears, the bed, A, being indicated, and the rack, B, dotted, because it lies *above* the mechanism drawn. The feed-rod, C (which lies in a plane below the gears, shown to the right, though drawn as though all in one plane), revolves the bevel gear sleeve, D, by a keyway and feather. The bevels at each end of D may be slid into engagement by the knob, E, with bevel, F, for feeding to right or left. F is keyed on spur pinion G, which rotates the wheel H, and the latter is caused to move the pinion, J, when the friction-disc keyed on the shaft of J is drawn into frictional contact with H by the screw knob L. The pinion, J, then turns the wheel M, with its pinion engaging in the rack. Hand movement is effected by the wheel, N, also having a pinion engaging with M. The self-acting cross traverse is produced by a pinion above H connecting it to another pinion on the cross-feed screw, the details not appearing in the view.

The stepped feed cones formerly employed exclusively for operating back-shafts have given place largely to gear drives, which are more powerful. Changes are made either by sliding different sets into mesh with each other, or by the use of a sliding key, in **15**. There are two shafts, one, A, on the end of which a spur gear is keyed, and driven by others from the mandrel. Three pinions are keyed on the other end of A, and constantly engage with three running loosely on the end of the feed-shaft, B. The shaft is grooved to hold a sliding key pinned into a collar, C, moved by the handle, D. When, therefore, the end of the key slips up into the keyway in any of the three loose pinions, that one starts to drive the shaft, B. Three rates are therefore obtainable by simply moving the handle, and other different ones by substituting fresh gears on the left-hand end of A.

Taper-turning Attachment. We have seen that tapered work may be produced either by swivelling the top slide of the rest or by setting the poppet over, the first for short tapers, the second for long ones. There is another device, more common in America than in England, which avoids the necessity of touching the poppet setting, and shown in **17**, a view looking down upon a 14-in. swing Pratt & Whitney *engine* lathe, as the most complete lathes are termed. The part of the slide-rest which moves at right angles across the carriage has an extension, to the end of which is pivoted a block, resting in a grooved slide supported on brackets at the back of the bed. The screw of the slide which carries the block is temporarily disconnected; if, therefore, the grooved slide is swivelled around to an angle with the lathe axis, the block in travelling must be coerced and drawn over, pulling the slide with it and so turning taper. The exact amount is determined by the setting, which is found by graduations on the grooved bar. This attachment is applied also to lathes cutting tapered screws, and holes may be bored taper.

Examples of Lathes. Having pointed out the main features of lathes of the more usual types, we may consider the general build and the modifications introduced for special functions. The types of lathes run into many dozens, but they all have something in common with each other. A typical English and an American lathe are seen in

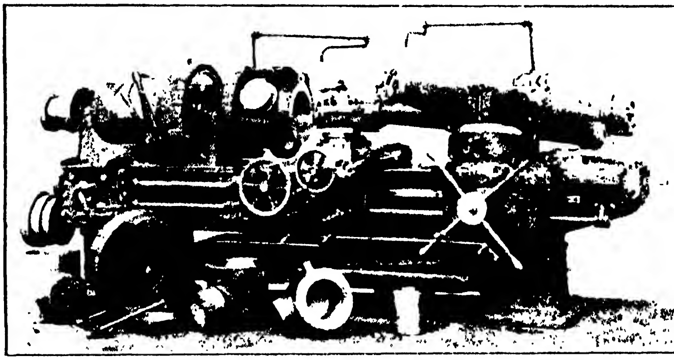
18 and 19, embodying many of the points already discussed. Fig. 18 is a gap lathe, and has lead-screw and back-shaft, while in 19 the lead-screw is splined to form a feed-shaft.

Fig. 20 is a modified type which in the carriage bears some resemblances to American practice, but the lathe is made massively for work with high-speed steels. The belt cones are much larger than usual. The feed-shaft is below the lead-screw.

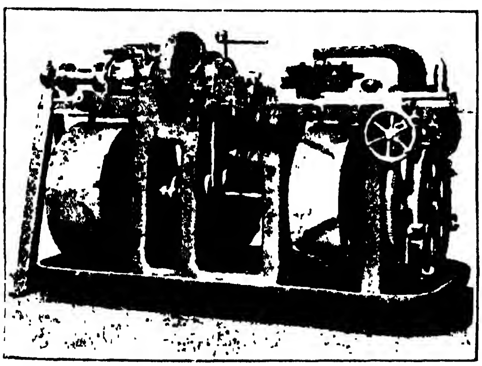
For work which does not require the use of a poppet—such as turning, boring and facing wheels, discs, etc, held on a face-plate or chuck, the surfacing and boring lathes are employed [21]. There is no lead-screw, but a number of changes of feed are obtained by gears in the box in front of the head and transmitted to the saddle by feed-shaft. The nature of much of the work done on these lathes requires frequent changes of spindle speed, as when facing across a broad disc. Messrs. Lang & Sons have brought out a new type of headstock, in which a range of speeds may be gradually merged from the slowest to the fastest, or vice versâ, by means of a special belt on expanding cones.

Break lathes are those having a large gap, produced by bolting the bed separately upon a *base-plate*, so making a break in the continuity of the surfaces. The base-plate carries one or two rests on pillars, and the separate bed also has rest and poppet. Fly-wheels are typical of the class of work done in these lathes.

Double railway wheel lathes are specially designed for turning a pair of wheels simultaneously on their axle. Figs. 24 and 25 show an example by Messrs. James Spencer & Co., of Hollinwood. There are two heads, A, B, the first of which is the main one. Its stepped cones, C, drive the pinion, D, and thence the spur wheel, E, the last being keyed on a shaft which runs through the bed, and drives each face-plate, F, G, simultaneously by a pinion beneath engaging in rings of spur teeth on each plate. By this means both wheels are driven and no torsion comes on the axle, which simply rests on the point centres fitted to each face-plate. The wheels are driven by pins, H H, shown on plate G, and the plate F is also fitted with four adjustable jaws, two of which are seen in front view in 25, to grip tyres for boring, when there are no wheels to be done. These jaws are moved radially by screws, and clamped with bolts. Several tee-slots are also made in the plate for holding the driving pins, H H. In order to accommodate differing lengths of axles, the head, B, is made to move along the bed by rack and pinion, seen on the front, a final adjustment of the point centre being effected by the hand wheel, J, operating gears, and thence a screw inside the cast-iron spindle. Axles are removed by working J to withdraw the centre sufficiently. A crane is, of course, necessary to carry the axles and wheels to and from the lathe. The slide-rests, K K, two in number as shown, or duplex, placed at front and back, are carried by pillars on sole plates, resting partly on an extension of the bed, and the necessary movements are imparted by working the upper slides either by hand or self-actingly. The self-acting feed is derived from a gear, L, driving another beneath it, and thence a slotted crank-disc, M, which reciprocates a connecting rod, N, jointed to one crossing the bed, O, and rocking a shaft, P, at the front. Two quadrants or part wheels, Q Q, reciprocate chains passing up over the wheels on the slide-rest screw ends, and ratchets inside these wheels give the screws an intermittent motion, feeding the rests bit by bit. This is a device much adopted in other types of lathes though it has given place in many cases to continuous feeding by shafts and gears. The rests, K, have two circular swivels, as seen, the object being to leave the lower one set for turning the tapered treads, while still being able to face straight across the sides of the wheels with the upper part set squarely.



30. MASSIVE LATHE WORKING ON HYDRAULIC JACK BODIES (Alfred Herbert, Ltd.)



31. AUTOMATIC SCREW MACHINE (Alfred Herbert, Ltd.)

Some lathe wheels have extra attachments in the shape of boring bars for boring out the bosses of wheel centres.

The *crank-shaft* lathes are characterised by massiveness and great length; they are employed for turning crank and other heavy shafting, especially for marine engines.

A number of slide rests are used. Some crank-shaft lathes have a couple of specially narrow rests, to pass between the webs of cranks which the ordinary rests could not reach. In such heavy lathes as these, and other kinds, the lead-screws are sometimes non-revolving, a nut being made to rotate around them instead, and so move the saddles along.

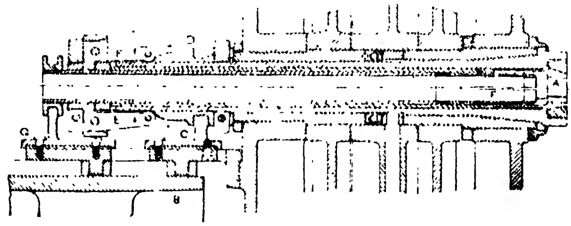
Gun lathes have some points in common with crank-shaft lathes, but, in addition, encircling

steady rests are necessary to support the bodies. In some the poppet is not used at all, but the gun is supported only at the headstock end, with one or more steadies between that and the other end of the gun. This permits the use of a boring bar working at the free end. When there is a poppet, support may be also given by a steady-rest. A lathe without poppet is seen in **22**, two steady-rests being in use, and the slide-rest is shown facing across the muzzle. Lathes adapted for boring include an extended bed, carrying a boring bench, from which the long bar is supported and fed into the gun. Rifling is also effected by a bar.

The lathes previously illustrated have all borne some resemblances to those of standard type, which were exemplified by **18**. Treating now of more specialised forms, we find that considerable differences occur in heads. In the *axle-turning* lathes [**23**] the head is placed in the centre of the bed length, leaving both ends of the axle free to be turned simultaneously, unencumbered by driving tackle. Two poppets are necessary, the point centres of which support the axle-ends. One of these poppets has a cross-motion by screw and handle, in order to allow space for the endlong withdrawal and insertion of axles. The head has a running sleeve driven by a train of spur gears, and two prongs standing out engage with the carrier bolted on the axle. The principle of such a head is shown on page 829 [**80**]. There is a crane combined with this lathe, to lift axles in and out.

Roll-turning lathes are of a rather plain character, but differ from ordinary practice by having supports or bearings in which the roll necks run during turning, instead of depending on the point centres.

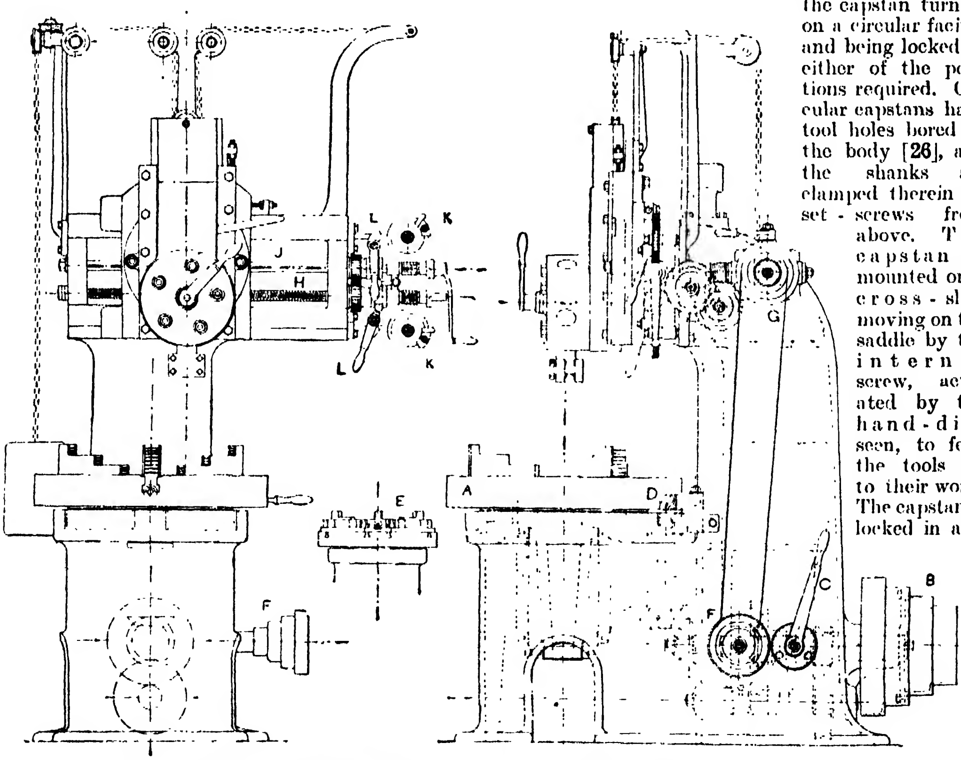
Pulley-turning lathes are employed to turn pulleys and wheels after their bosses have been bored out on some other machine, the wheel being then put on a mandrel in the lathe, and the rim turned with a special slide-rest, which may have provision by a curved slide for putting on the "crowning" which helps to retain a belt on a pulley.



32. DETAILS OF AUTOMATIC WIRE FEED

The subject of capstans opens up a wide field. The introduction of the fitting has created many new types of lathes and modified others. It is a simple idea, that of arranging a set of tools for a given job on a revolvable mounting, so that instead of having to loosen bolts, take out tools, and insert others (as in the ordinary lathe) any tool may be brought into action by the simple motion of a handle. The usual provision in capstans (or turrets) is for five or six tools. Some of square shape carry four; others of octagonal form hold eight.

The plainest type of capstan has four recesses or ledges in which tools are pinched with set-screws, the capstan turning on a circular facing, and being locked in either of the positions required. Circular capstans have tool holes bored in the body [**26**], and the shanks are clamped therein by set-screws from above. The capstan is mounted on a cross-slide moving on the saddle by the internal screw, actuated by the hand-disc seen, to feed the tools up to their work. The capstan is locked in any



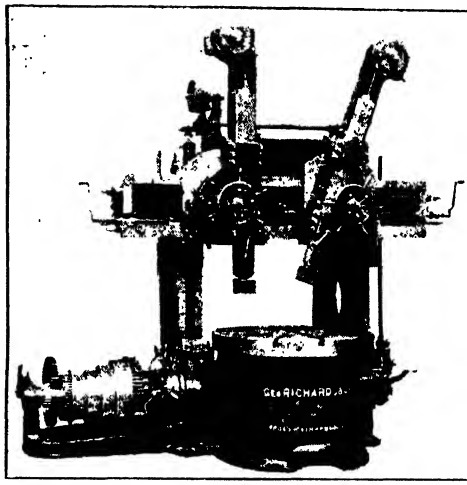
33. VERTICAL LATHE OF 30-IN. CAPACITY (Webster & Bennett, Ltd., Coventry)

of its five positions by notches around the base (seen in the plan view), the pivoted handle, A, being pulled back a little sufficiently to revolve the capstan with the hand, and then let go, when the projection on the handle slips into a notch, as seen, the coiled spring in the box, B, retaining it there through the pressure of its plunger on the end of A.

A lathe with capstan similar in style to **26** is illustrated in elevation and end view in **27**. It is of the *open-spindle* design, a kind that has long been in favour for producing bolts, studs, screws, pins, etc., from long pieces of bar passing through the head, and cut off as each piece is turned. The special value of the long opening through the spindle, A, between the bearings, is that bolts and pins with heads may be inserted and pushed into the gripping chuck at the nose, the opening forming a space for the head which is not obtainable in ordinary bar chucks unless the jaws are made to open widely. The chuck of A is tightened or loosened with a large spanner on the outside, the bar being gripped with taper-body jaws closed in by the action of the nut.

The spindle is locked during the use of the spanner by handle, B. Driving is effected by the four-speed belt cone, C. The self-acting movement of the saddle is produced by belt from the small pulley, D driving E, the latter transmitting motion to the feed-shaft, F, through the box of change-gears interposed, giving three changes, by the handle, G. The shaft, F, turns a sliding worm in the box on the saddle, rotating a worm-wheel on the rack pinion shaft. Hand movement is effected by a handle on the squared end of the worm and rack pinion shaft, the feed being thrown out of action by the small cross-handle seen. Adjustable stops are mounted on a bar, H, to arrest the travel of the saddle at predetermined points for repetition work. There is a *die-head* at the back of the saddle, that may be thrown back out of the way when not required for screwing bolts, etc.

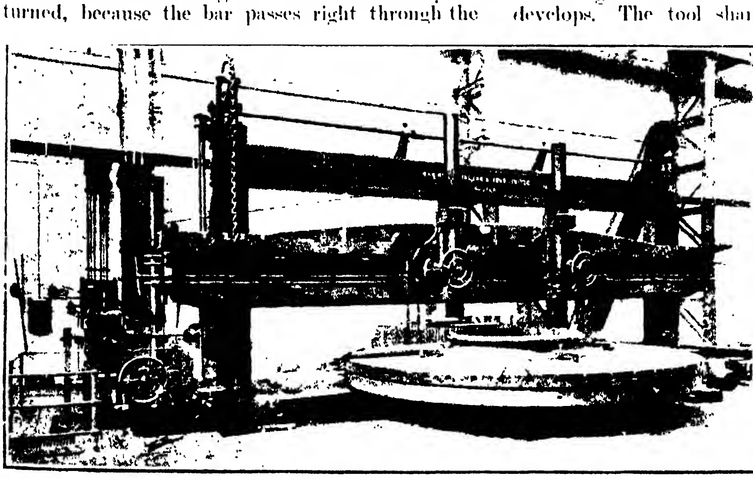
The capstan in these illustrations is what may be termed the "side-set" type, because it is placed in front of the work, and presents tools in holders resembling those used in the ordinary slide-rest. As there is no support to the bar away from the chuck, it is impossible to turn a long piece without it springing even if a poppet is used. But with another kind of capstan which is centrally set in line with the lathe axis, lengths of several feet may be turned, because the bar passes right through the turret, and is steadied by guides combined with the tools—box tools. For such long movements it is clearly impossible to have a central bolt standing up in the turret centre, as in **26**, and a sort of turntable device is therefore adopted, leaving an open area inside the turret.



34. VERTICAL LATHE WITH TWO TOOL SLIDES
(George Richards & Co., Ltd., Broadheath)

When the length of work is short enough to allow of a central bolt standing up, the construction shown in **28** is followed. The base portion, A, is clamped to the bed, and the slide, B, moved up to and back from the headstock by the pivoted handle, C; the stop-screw, D, at the rear arrests the movement positively. The capstan is not revolved and locked separately, but time is saved by making the backward travel perform the part rotation. It will be seen from the plan view, in part section, that a ratchet is placed in the capstan base; one of the teeth strikes against the lever, E, pivoted in the base, A, and thus forces the capstan to make a part revolution. A locking plunger, F, is drawn out of one of the notches seen in the capstan before the revolution, and thrust into the next notch as it comes round. A gib strip is laid alongside F to take up its slack when wear develops. The tool shanks are not held in the capstan by plain set-screws, but by pads and bolts, as shown in the detail G. The shank is gripped between the concave edges of the bolt and its pad without any damage being caused to the surfaces.

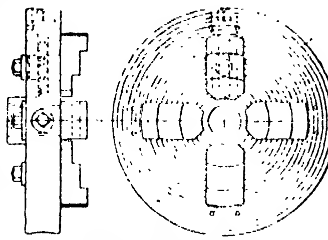
A lathe (by the makers of **28**) with hexagon hollow turret is illustrated in **29**. The saddle is moved along the bed by the large cross-handle at the front, or by power from the gear-box in front of the headstock. The headstock is unlike any we have shown, the various



35. HEAVY VERTICAL LATHE FOR 30 FT. DIAMETER
John Hetherington & Sons, Ltd., Manchester

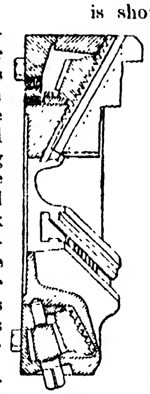
speed changes being derived from toothed gears inside the casing, there being only one belt pulley. The chuck on the spindle nose is opened and closed by the lever while the lathe is running. The tray and oil guards in it may be noted.

A more massive type of lathe [**30**] is shown working on forged steel hydraulic jack bodies, the turret carrying boring and facing tools, and the cross-slide facing tools on a square turret.



36. 4-JAW CHUCK

Turret lathes which carry through their operations without attendance are termed *full* automatics, to distinguish them from *semi*-automatics. Automatic screw-machine is a more specific term, because screws and bolts were the primary objects produced at first, though the scope has been much extended. The various motions are effected by cams, usually on drums and discs beneath the framing [**31**] operating pins and levers to open the chuck, feed the bar forward, grip it, work the turret and the cross-slides, and in some cases to chuck separate castings in succession, all automatically. The cam strips seen on the large drums are bolted down at various angles [see pages 4323 and 4324] so that as the drums revolve the strips coerce the operating pins projecting down below the head and the turret slide.



37. SELF-CENTRING CHUCK

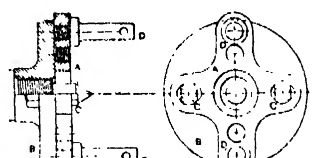
The feeding and chucking mechanism of automatics, termed *wire-feed* (also fitted to hand capstan lathes), includes a split, springy nose [A, **32**], which, when pushed outwards, closes in and grips the bar inside it. The end motion is given by a cam strip (not shown) on the drum, B, pushing slide, C, along, with it the circular sleeve, D, so thrusting apart the toggle levers, E, and making their other ends thrust the tube of A along. The feeding forward of the bar is effected by the split tube, F, which grips the bar with sufficient friction to move it forward when the chuck is opened. F is slid by the slide, G, at the end. also actuated by a cam strip. In hand-operated feeds, the places of C and G are occupied by differently designed fittings, slid by levers. The spindle, as shown, has three pulleys, one central fast one and two side loose ones, having reverse belts, either of which may run on the central pulley to drive it in one or another direction.

A class of lathe which usually includes a turret is the chasing lathe, that cuts screws by the use of a hob—a short screw—moving the nut of the slide-rest.

Boring and turning mills, or vertical lathes, have the advantages arising from the horizontal position of their tables. A mill of 30-in. capacity in diameter is illustrated [**33**] to show the essential points of such machines. The table, A, has a large taper spindle, and it runs upon an annular ring bearing close up under the face-plate or chuck. A spur-wheel, the bottom of which forms the running portion, rotates the table, being actuated from the train of gears seen inside the frame, primarily driven from the cone pulley, B. The handle, C, moves clutches to obtain two different speeds. A brake, D, arrests the table quickly by hand, to examine work. E is an alternative style of table with loose jaws. The turret head slide has cross and down feed derived from the pulley, F, which is belted up to a cone, G, whence a train of gears connect to the screw; H, for cross-traverse, and the splined shaft, J, for down feed, produced through gears inside the turret slide. The latter can be swivelled for tapered turning or boring. The worm-wheels, K K, are for throwing out the feed motions at any desired point; these wheels are rotated slowly by worms on the feed rod and shaft, and have dogs clamped to their faces by circular tee-grooves. The dogs are set to strike the levers, L L, at a certain point of the rotation, and so to throw out clutches on the rod and screw, stopping their action. The entire slide is counter-balanced by the weight and chains seen.

A mill with two tool-slides, not having capstans, is shown in **34**. The balancing of the tool rams is by enclosed springs, obviating the use of the rather clumsy chain and weight device. A mill of the heaviest class, taking 30 ft. diameter [**35**], involves a large amount of work which is not visible, being below the ground level. The table normally runs on an annular path of nearly the full diameter, but a footstep is placed at the bottom of the spindle, and a screw device is fitted to raise the weight of the table off the large path and take it on the small step, which results in easier and lighter running for trial chuckings and light boring.

We have noted several chucks incidentally in the various lathes. When the chuck is made separately, to screw on to the spindle nose, it is usually of the four-jaw pattern [**36**], with the jaws moved radially by square-threaded screws, and clamped by nuts and washers on the back when the work is set truly. The jaws are moved independently, and circles are scribed on the chuck face to set approximately by. Self-centring chucks have all the jaws moved simultaneously, of which **37** (by Charles Taylor, Birmingham) is an example. The three jaws are operated by threads on their backs, moved by a ring having a set of spiral grooves radiating from the centre. One of three bevel pinions is turned by a square-hole handle to revolve the spiral ring. Both independent and concentric motions are included in some chucks. Another important accessory to the lathe is the Clements driver [**38**], an improvement on the single pin driver plate, shown in **8**, which bears only on one side of the carrier on the work, resulting in unequal pressure. The equalising driver here shown consists of a loose plate, A, held against the face or *catch*-plate, B, by a couple of bolts, C C, fitting in slots in A. Driver pins, D D, are screwed into A, two sets of holes of different radii being available. As the pins, D D, come into contact with the opposite ends of the carrier the plate A slips until they bear and drive with equal pressure.



38. CLEMENTS' DRIVER

Continued

HOW TO BECOME A FORESTER

Forest Pests and How to Fight Them. Forestry as an Industry. Wood Pulp. Theoretical and Practical Training. Best Books

FORESTRY continued from page 4690

By HAROLD C. LONG

UNDER the term *forest pests* it will be convenient to consider several agencies which are deleterious to forest trees, and not only such of them as insects and fungi. Among these agencies wind, snow, frost, fire, domestic and wild animals, birds, weeds, insects, and fungi may be included. All these have a very great influence on the success or failure of the forest to produce good timber ; and, while the damage wrought by the two last is generally admitted to be the most serious, yet that due to the other agencies is frequently enormous.

Wind. Very considerable harm is often done in positions where the full force of high winds is felt, whole plantations being at times razed to the ground by almost cyclonic force. In very exposed situations storm-firm species should be planted ; deep and shallow rooted species may be intermixed ; and shelter-belts may be employed, these being left when the wood is cut over, the trees thus becoming hardened and adapted to their environment. Or the system may be such that the successive cuttings are arranged to take place *towards* the direction from which the prevailing storms come, the tops of the trees then forming a kind of inclined plane over which the wind may sweep.

Snow. In countries where heavy falls of snow are experienced, snow lodging on the trees in masses may do great damage by breaking branches, and by bending and breaking the tops, especially in the case of comparatively young conifers. Intermixing the species may help somewhat in obviating trouble.

Frost. Intense frost may cause longitudinal cracks in the stem, often extending deeply into the tree ; and small plants may, in light soils, be lifted almost out of the ground by expansion of the absorbed water, falling over when thaw supervenes. In nurseries a covering of leaves may prevent very considerable damage ; damp soils should be drained ; and nurses of hardy species, for example, birch, may be established for tender species.

Fire. Fires are chiefly caused by railway locomotives, careless throwing down of matches, and camp fires. Surface fires, where litter, bushes, etc., are concerned, may often be beaten out with green branches ; while crown fires, which are often due to surface fires, may be arrested by cutting or felling a belt of trees across which the fire cannot pass. In some countries—for example, the United States—enormous damage is sometimes done by fire. The great fire of Minnesota, in 1904, destroyed a huge tract of country, including seven towns ; many lives were lost, and the damage caused was estimated at some five millions sterling.

Weeds. Weeds of all descriptions should be allowed no place in a forest, as they do considerable harm by hindering natural regeneration, while they aid in preventing percolation of water, hinder the growth of young trees, and harbour injurious animals and insects. Under a good forest cover, where the soil is little exposed, weeds will be kept in check.

Animals. In the past it may be said that woodlands have, in a majority of cases, been looked upon more as game preserves than as anything in the nature of timber producers. This position must be abandoned before the best results can be obtained. Rabbits, hares, and deer, all do much harm by "barking" trees, etc., as also do squirrels, which frequently completely girdle young top shoots, which, in consequence, die off. Black game and pigeons are also injurious, the former nipping out the buds of conifers and the latter breaking off the leading shoots of spruce. Small birds may occasion loss in the nursery. Most birds are, however, useful to forestry owing to the fact that they devour insects.

Insect Pests. A large number of insects are injurious to forest trees, the most harmful of all being those which attack conifers. In the United States of America it has been estimated that the average annual loss due to insect pests of the forest approaches £20,000,000 sterling. Damage may consist in defoliation of trees, spoliation of buds, and injury to the bark and timber, and by such means the increment of the wood is interfered with even if the trees be not killed, as they too frequently are. Let us consider some typical species of injurious insects.

The Cockchafer. Not only to farm crops but also to forest trees cockchafers are exceedingly harmful. The cockchafer (*Melolontha vulgaris*) is assisted by the summer chafer (*Rhizotrogus solstitialis*) and the garden chafer (*Phyllopertha horticola*) in its work of destruction. In the larval stage they are known as "white grubs," and feed at and damage the roots of almost all kinds of crops and small forest plants, thus retarding the growth of the plants or killing them. The life history extends over three or four years, during most of which time they are feeding as grubs. In the mature, or beetle, state, also, they are still harmful, feeding on the leaves of forest trees, particularly the broad-leaved species. The foliage is much damaged and the trees are sometimes quite stripped. Young oaks and pine trees often suffer severely. In England this insect is a pest in nurseries but does little damage to trees in plantations. [See NATURAL HISTORY and PLATE facing page 3361.]

The beetle [10] is about one inch in length, and when at rest presents a reddish-brown appearance. The whitish fleshy grubs are over an inch long, and when fully grown have three pairs of legs, and strong, biting jaws. The chief method of destroying the pest is by collecting the beetles, as is done on the Continent, where they are paid for at the rate of about 6d. to 1s. per bushel. The larvæ also may be trapped by laying on the ground pieces of turf, grass downwards, the grubs collecting beneath. The beetles are eaten by fowls and nightjars, while starlings, rooks, and plovers are very partial to the white grubs.

Large Pine Weevil. The very harmful beetle the large Pine Weevil (*Hylobius abietis*) lays eggs on stumps, in which the resulting larvæ soon burrow, the mature beetles coming forth during the following summer, and gnawing off the soft and young bark of the Scots fir, larch, spruce, etc., quite young plants being attacked. The beetle [9] is about half an inch long, and dark brown in colour with white markings. Protective methods consist in the removal of stumps and roots, which may be burned with all rubbish. Plants of mixed species may be used for planting. Destructive methods consist in sticking in the ground young branches and poles of pine and spruce in full sap, or laying down pieces of the bark outside upwards. The former will be used for egg-laying, while the beetles will collect under the latter for feeding. The branches may be burned, and the beetles under the bark destroyed. Newly-felled areas may be separated from newly-planted areas by trenches of a foot in depth. Although they can fly over, the beetles are sluggish, and many will fall into the trenches in crawling, and may be destroyed.

Pine Beetle. Pine beetles (*Hylurgus piniperda*) bore galleries between the bark and the wood in the stems and larger branches of Scots and other pines, eggs being laid on dead or dying trees when possible, the resulting larvæ boring in the inner bark. After pupating there, the beetles eat their way to the exterior, and when many beetles are present the bark of the trees may have the appearance of being "shot-holed." Mature beetles [8] now pass to the young shoots of pines, and bore their way up these, eating the pith, and causing the shoots to break off or die, this being the chief cause of damage. Sickly trees should be removed. Trees felled in autumn and winter should be left until near the end of May, when, if they are barked, all larvæ between the bark and wood are destroyed. Traps of poles, employed from February to September, will attract the insects for egg-laying, and the bark may be burned. The beetle is about one-fifth of an inch in length, and almost black in colour.

Pine Sawfly. The larvæ of the Pine Sawfly (*Lophyrus pini*), as well as those of its relative, the Fox Pine Sawfly (*L. rufus*) do enormous damage to young pines, the needles being eaten, and the bark on shoots being gnawed away [12]. The larvæ feed during June and July, and a second brood perhaps in autumn. They resemble the caterpillars of moths and butterflies, but bear twenty-two legs. They are green in colour with black eyes. As the larvæ occur in groups they may be destroyed by crushing, or they may be jarred off the trees on to boughs spread beneath, and then burnt. Spraying ornamental trees with lead arsenate, or hellebore, will quickly destroy the caterpillars. In large woods (it is recorded that in one instance 2,000 acres were invaded) it is almost impossible to cope with the pests, but all leaves, moss, and rubbish beneath the trees and containing the cocoons may be collected and destroyed.

Oak Leaf-roller Moth. The little Oak Leaf-roller moth (*Tortrix viridana*) lays eggs on oak trees, and the resulting greenish caterpillars, about half an inch long, destroy the leaves, rolling them up characteristically [11.] The loss of leaves causes a loss in timber production.

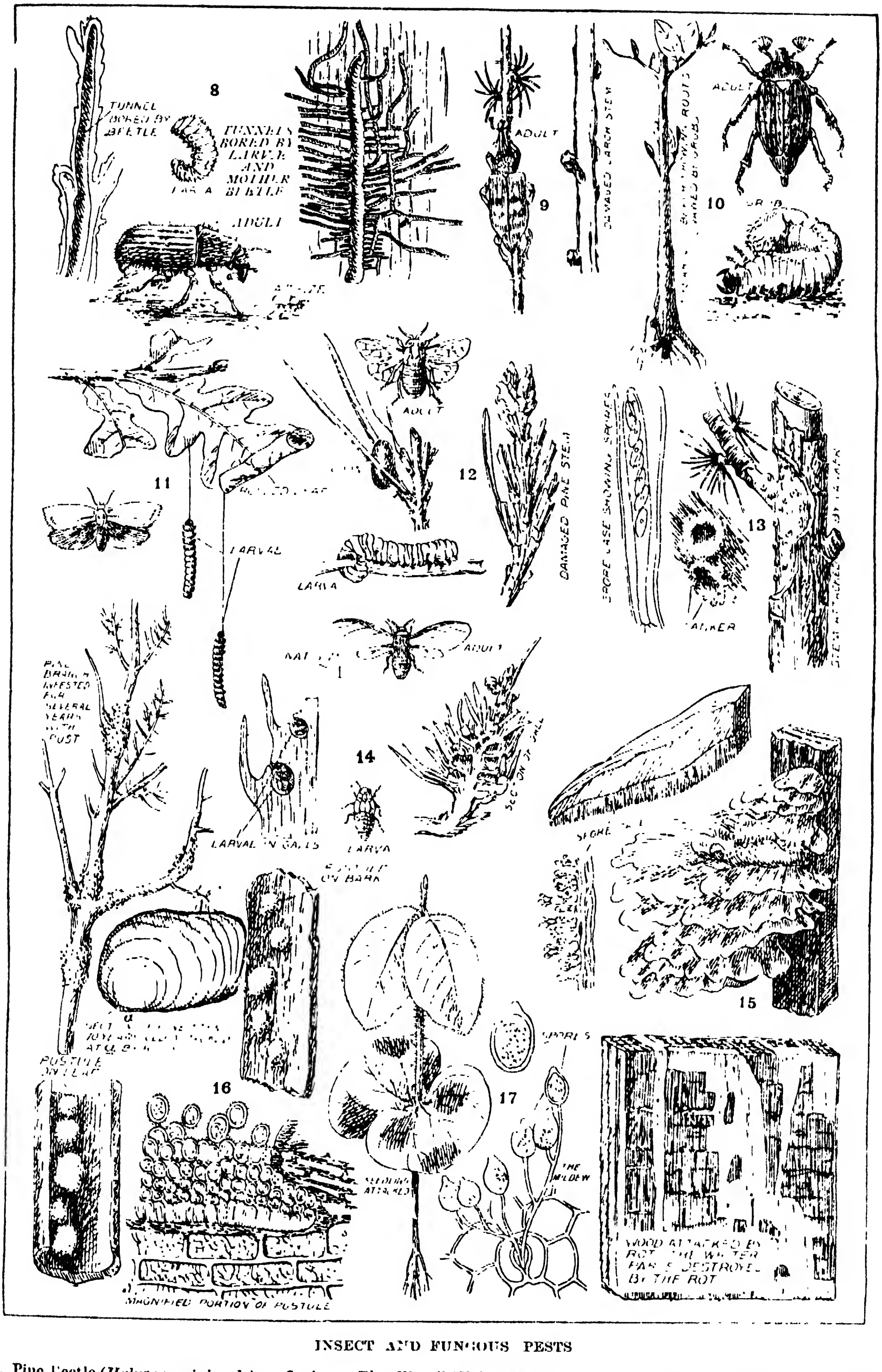
Spruce and Larch Aphides. Among the aphides, or plant-lice, one of the most harmful is the species which infests the spruce and larch [14]. The life history of these little creatures is somewhat complex, but it may be noted that, piercing the young twigs of the spruce, *Chermes abietis* gives rise to galls, from which a generation may issue and fly to the larch, when the aphides are known as *Chermes laricis*. These pierce the needles and suck the juices, and the trees appear as though lightly besprinkled with snow. Much damage is done, the needles become "kneed," and weakening of the trees may culminate in their death. Much good may be done by spraying infested trees with soap and paraffin emulsion, but this can hardly be carried out on a large scale.

Other Insect Pests. Many other insects are very harmful to forest trees, and amongst these it may be mentioned here that the Pine Shoot Moth (*Retinia buoliana*) hollows out and damages the leading shoots of Scots pine; the larvæ of the Giant Wood-wasp (*Sirex gigas*) live in and tunnel the timber of pines; the large caterpillars of the Goat Moth (*Cossus ligniperda*) tunnel the stems of many broad-leaved species (elm, ash, beech, etc.), rendering the wood useless as timber; and the minute Felted Beech Coccus (*Cryptococcus fagi*) is most destructive to the beech, the bark being pierced and the juices sucked.

It should be noticed also that many insects are useful to the forester, owing to their habit of preying on injurious species, and among them certain lady-birds (*Coccinellidae*), species of Ichneumon flies, *Clerus formicarius*, and the genus *Rhizophagus*, are of much value. [See Natural History.]

Fungous Pests. Many fungi greatly affect the forester, some attacking the base of the stem and the root system, others the main stem and branches, and others the leaves. While the most important species are to be found among fungi which attack conifers; yet many are injurious to broad-leaved species. The following are typical examples of injurious fungi:

Larch Canker. The terrible scourge Larch Canker (*Dasyscypha calycina* or *Peziza Willkommii*) is one of the most harmful of fungi, and is much feared. It occurs almost wherever the



INSECT AND FUNGOUS PESTS

8. Pine Beetle (*Hylurgus piniperda*) 9. Large Pine Weevil (*Hylobius abietis*) 10. Cockchafer (*Melolontha vulgaris*) 11. Oak Leaf-roller Moth (*Tortrix viridana*) 12. Pine Sawfly (*Lophyrus pini*) 13. Larch Canker (*Dasyscypha calycina*) 14. Spruce Gall Aphis (*Chermes abietis*) 15. Root Rot (*Trametes radiciperda*) 16. Pine Blister (*Peridermium pini*) 17. Seedling Mildew (*Phytophthora omnivora*)

larch is found. The stem and branches are attacked, most harm being done to seedlings and young trees [13]. The disease, according to "Diseases of Forest Trees," published by the Board of Agriculture in 1905, is "caused by a minute cup-shaped fungus, which acts as a wound parasite, gaining an entrance into the tree through minute fissures in the bark, caused by late spring frosts, or through the punctures made by the larch aphis (*Chermes laricis*)." Trees are killed when *ringed* by the fungus. Damp, low-lying situations should be avoided. Larch aphis should be suppressed. Diseased trees should be felled and burned. Pure larch woods must be avoided. A system of combating this disease which promises to provide a satisfactory solution of the difficulty is described in the "Journal of the Board of Agriculture" for March, 1906.

Root Rot. The base of the stem and the root system of conifers are attacked by Root Rot (*Trametes radiciperda*) [15]. Massee says that it is probably the most destructive of fungi attacking coniferous trees, and that as the disease may spread by contagion by the roots, "diseased trees should be removed at once, and the site isolated by a narrow trench, taking care to include within the trench all roots of the diseased tree." Perhaps the best plan is to plant broad-leaved trees where attacked conifers have left blanks.

Pine Blister, or Conifer Rust. The leaves alone may be attacked by Pine Blister (*Peridermium pini*), when the injury will be negligible, or the branches or upper part of the stem may be infested, the disease finally reaching the wood, in which case the upper branches die, giving rise to "resin-top" or "blister." As the fungus passes one stage on the leaves of Groundsel (*Senecio vulgaris*) and Ragwort (*S. Jacobæa*) these weeds should be kept down. Affected trees should be cut down. Various pines are attacked [16].

Seedling Mildew. Seedlings of various trees are frequently attacked by a disease commonly known as "damping off." Beech seedlings are especially liable to be attacked by this mildew (*Phytophthora omnivora*), which causes the young plants to rot off near the base of the stem at the surface of the ground [17]. Diseased plants should at once be removed and destroyed, and the beds sprayed with a Bordeaux mixture of half the ordinary strength (2 lb. copper sulphate, and 1 lb. quicklime, in 20 gallons of water). Seedlings should be grown in open situations, and not damp, sunless positions, for, as the name implies, the disease is favoured by damp.

Other Fungous Pests. Other fungi, also, are very injurious, such as Heart-wood rot (*Polyporus sulphureus*) which attacks all our forest trees; Tinder fungus (*Fomes fomentarius*), a large "bracket-like" fungus especially found on beech; Honey agaric (*Agaricus melleus*), which proves fatal to both old and young trees, especially Scots pine and spruce; the Needle-shedding fungus (*Hysterium pinastri*), which does great damage to Scots pine by causing the needles of the young plant to fall, and many others.

Forestry and Industry. Though it must be freely conceded that under the comprehensive study of forestry such questions as landscape forestry, the influence of forestry on climate, prevention of erosion and avalanches and so on, all fall to be considered, it is as an *industry* that forestry is especially dealt with in this course. As has been shown, not only are well-managed forest lands profitable to the owners, but in large forest districts minor industries spring up, and give rise to the profitable employment of great numbers of rural workers. In addition to the ordinary timber trade, in which so many capable men are profitably employed in Great Britain, the manufacture of wooden utensils, and so forth, other industries depend to an enormous extent on the production of good timber of a certain class. The beech woods of the Chiltern hills gave rise to a chair industry which led to the employment of thousands of men. Artificial horsehair and yarn, oxalic acid, acetic acid and other products are valuable articles prepared from timber. An excellent artificial silk, not so elastic and strong as the real material, but equal to it in lustre, can be prepared from the cellulose made from spruce timber.

Wood-pulp. An example of an important industry is papermaking from wood-pulp, which is dealt with in the course on PAPER AND PAPER-MAKING. In 1903, Great Britain imported 576,153 tons of wood-pulp of the value of £2,506,583, by far the larger proportion coming from Scandinavia. Not only is wood-pulp utilised for the production of coarse grades of pasteboard, but mechanically prepared pulp is chiefly employed for the manufacture of inferior grades of paper. The trees most suitable to pulp making are young trees of about 20 years old, and 6 in. to 20 in. in diameter at the base. Soft, coniferous woods are most suitable for the chemical process, the species chiefly used in Europe being spruce and silver fir, while for the production of mechanical pulp, these two species are used, together with ash, birch, and poplar. The cost of the wood required for the production of one ton of dry pulp is estimated at 13s. 6d. to 22s. in Canada, and 25s. to 30s. in East Norway, while the net cost of producing wet pulp (the values being expressed per ton of dry material) is estimated at £1 17s. 6d. to £2 10s. in Canada, and £3 in modern Norwegian mills, or 5s. less in Sweden. It is also stated that on a fair estimate the daily requirements of a large London paper would represent about 10 acres of an average forest.

How to Become a Forester. Whether it is worth while becoming a forester or not will depend on several matters, and not the least on the inclination of the student for the work to be undertaken, and upon the ultimate end he has in view. In Germany, the excellent schools enable the students to get a good grasp of their subject, but upward progress is slow, high rank in the forest service being in general attained only after long years of hard and faithful work. In Great Britain, such training as is given on the Continent is unobtainable, but forestry education is rapidly

improving, and more teachers will almost certainly be in demand within the next few years, while skilled and competent men will, no doubt, be required to supervise private and other planting. The Indian Forest Service is also attractive, and has within the last year or so had to refuse the loan of officers to other States, owing to the shorthandedness of the staff, while men appear to be in requisition in Africa, Ceylon, Siam, and various Colonies. For the youth fresh from a good school or for the young man at college, who is able to devote a year or two to practical training, it may be said that forestry offers plenty of scope for obtaining a livelihood. Remembering what we have seen above, as to the importance of our subject in all parts of the world; in view also of the fact that capable forest officers are even now in request in many parts of the British Empire, it will be recognised that the prospects for the forester of the higher grade are, in the near future, likely to be good. At present, however, the remuneration of the forester in Britain is altogether inadequate. Woodmen, perhaps, earn rather more than agricultural labourers on the whole, but the most important positions are, with a few notable exceptions, of small value, and scarcely likely to attract the better class of well-educated college-trained men. For the energetic young man, however, who has some capacity, who sticks to work, and is glad to devote himself to his subject, there is no doubt a future.

Instruction in Forestry. In Great Britain, theoretical instruction is given at several of the agricultural colleges and universities, notably at Edinburgh University, the University College of North Wales at Bangor, the Durham College of Science, and the Royal Agricultural College, at Cirencester. There is a school of forestry for woodmen in the Forest of Dean, under the control of his Majesty's Commissioners of Woods and Forests; and courses have lately been started at Oxford and Cambridge Universities. There is also a course in Forestry at Wye College, in Kent.

Not only, however, is theoretical instruction in forestry necessary for the student who wishes to take up this subject as a life's work, but several allied subjects must be studied with it, and their relation to it recognised. The courses for the B.Sc. degree and other diplomas in agriculture at our universities and colleges, substituting forestry for agriculture and omitting such a subject as veterinary hygiene, might form an excellent theoretical training. Geology, botany, zoology, entomology, surveying and engineering field-work, chemistry, and physics are all important, and should be studied to some extent at least.

Practical Training. While theoretical study is very necessary it must be distinctly understood that a sound, practical training is absolutely essential. To some slight extent this can be obtained in Great Britain, and in the course of the next decade or so the British student may be able to obtain a complete forest training in his native country. At present this is unfortunately impossible, for, although there are some well-managed woods, they are generally inconveniently situated as regards the centres of learning, while there are no demonstration areas and nurseries properly so called. Such areas are even more necessary in sylviculture than can be the case in agriculture, as results in agriculture may usually be seen by the farmer in a single season, whereas in sylviculture this is not so, a long series of years being necessary. It is of the utmost value to the student to see and study forest crops in different stages of development, and grown under correct systematic management. Without such, indeed, he is unable fully to comprehend sylvicultural methods. At several of the centres of instruction above-mentioned, a certain class of woodlands under management may be visited and examined, this being especially so in Edinburgh, where the proximity of several well-managed wooded areas is highly satisfactory.

A Demonstration Area in Wales. A 50-acre demonstration area and experimental station is being started in North Wales under the control of the Denbighshire County Council. This area will certainly prove of much value. It may be said, however, that although we are beginning to realise the need of forestry education, we are seriously handicapped as regards practical sylvicultural training. Several excellent permanent nurseries exist in several parts of the country, planting is being carried out, and sound systems of management are being inaugurated. Of such the students should see as much as possible. To obtain a thorough grounding in sound sylvicultural principles, a year or two should be spent at one or other (or two) of the French or German schools of forestry, of which there are many of a first-class character. This has in the past been the principle of the Indian Forest Service, many of the officers having received their training in Germany, and at Nancy, in France. At the present time, however, students can be trained in India.

The Best Books on Forestry. For further information on the whole subject of forestry, the following works may be consulted.

"Economics of Forestry," by B. E. Fernow (Spon. 7s. 6d.); "Timbers and How to Know Them," by R. Hartig, trans. by W. Somerville (Douglas. 2s.); "Diseases of Trees," by R. Hartig, trans. by W. Somerville and H. M. Ward (Macmillan. 10s. 6d.); "The Forester," by J. Nisbet—Brown's "Forester," revised 1905 (Blackwood. 2 vols., 42s.); "Our Forests and Woodlands," by J. Nisbet (Dent. 7s. 6d.); "British Forest Trees," by J. Nisbet (Macmillan. 6s.); "Studies in Forestry," by J. Nisbet (Clarendon Press. 6s.); "Manual of Injurious Insects," by Miss E. A. Ormerod (Simpkin, Marshall. 5s.); "Manual of Forestry," 5 vols.—I., Introduction to Forestry (6s.), II., Formation and Tending of Woods (8s.), and III., Forest Management (9s.), by W. Schlich; IV., Forest Protection (9s.), and V., Forest Utilisation (12s.), by W. R. Fisher—(Bradbury, Agnew); "Timber and Some of its Diseases," by H. M. Ward (Macmillan. 6s.); "Practical Forestry," by C. E. Curtis (Crosby, Lockwood. 3s. 6d.); "English Estate Forestry," by A. C. Forbes (Arnold. 12s. 6d.).

FORESTRY *concluded*; *followed by* RUBBER AND GUTTA PERCHA

Group 2 **GLASS** **3** Continued from page 4736	

ORNAMENTAL GLASS

Optical Glass. Coloured Glass. Venetian Beads. The Uses of Water-glass. Glass Decorating and Etching. Silvering Mirrors

Optical Glass. The glass used for optical instruments is now obtainable in great varieties, each kind differing optically in its effect on the light rays passed through it. Dollond was the first to put *flint* and *crown* glass together to make a lens in which each corrected the colour effect of the other. Chance Brothers, in 1848, produced a number of special *silicate crowns* and *flint* glasses for optical purposes, and have since produced other *barium* and *boro-silicate* glasses. Dr. Schott, in 1883, took up the subject of optical glass, and established the now well-known Jena Glass Works. The firm of Schott & Gen now make sixty-eight different kinds of optical glass.

Opal Glass. Opal glass, alabaster glass, enamel glass, bone glass, and milk glass are names given to glass which has been rendered opaque by the addition of calcium phosphate, tin oxide, arsenic, felspar, talc, zinc oxide, fluorspar, or cryolite. The degree of opacity varies even with the same receipt, but more certainty of obtaining a given result is claimed when covered pots are used. Glass made opaque with talc (French chalk) is known particularly as *alabaster glass*. Calcium phosphate is added in several forms, bone ash and guano being less pure agents, which owe their power of imparting opacity to the calcium phosphate they contain. Tin oxide is not now often used. Cryolite produces a beautiful *opal* or *milk* glass, but is difficult to work on account of the corroding fumes of hydrofluoric acid that are given off and do much damage to the furnace.

Coloured Glass. Coloured glass is coloured throughout or *flashed*. The latter term means that the body of the glass is ordinary transparent glass, and has been covered with the coloured glass. The workman has before him two vessels of glass, one white and the other coloured. He dips his blowpipe in the white pot, and having collected a lump of the required size, he dips it into the pot of coloured metal, and proceeds to blow the glass in the manner described in the section on *window glass*.

Red glass is obtained with cuprous oxide, gold salts, antimony oxysulphide, or selenium salts. A red colour is also sometimes obtained with ferric oxide or red ochre. Purple of cassius is the salt of gold mostly used. The quantity of gold required to impart a rose colour to glass is exceedingly small. The receipt for red glass in which antimony oxysulphide is used is: Silica, 100; calcium carbonate, 20; sodium carbonate, 50; sawdust, 7½; antimony, 4. A smaller proportion of antimony gives a yellow. The colour develops in gold and copper glass on cooling.

Blue glass is obtained with copper oxide (black), cobalt oxide (or zaffre or smalts), and sometimes from iron. *Smalts* is a powdered cobalt glass and *zaffre* an impure form of cobalt oxide.

Violet glass is yielded by manganese oxide.

Green glass is made with chromium oxide, bichromate of potash, or a mixture of antimony oxide and cobalt.

Yellow glass is obtained from uranium oxide, antimony oxide, sulphur, silver salts, or carbon. The colour obtained with carbon varies from yellow to brown, according to the quantity used. Glass is coloured with silver by applying a salt of silver to the surface of the glass at a temperature of 500° to 550° C. A lace design is given by dipping a piece of lace in a silver solution, followed by a solution of potassium sulphide, and then placing the lace on the heated glass.

Orange-coloured glass is obtained from a mixture of iron oxide and manganese oxide.

Black glass is produced from a mixture of iron, copper, manganese, and cobalt oxide. Iridium oxide and sulphur have also been used for obtaining black glass.

Dichroic or two-coloured glass is obtained from uranium oxide with copper oxide or selenium. Such glass is yellow when light passes through, but greenish when looked at.

Aventurine glass is a glass made to imitate aventurine quartz or gold stone, which exhibits beautiful gold-like spangles throughout. It was formerly only made in the Island of Murano, near Venice. The following are receipts for two varieties of this beautiful glass. *Green aventurine:* Silica, 100; sodium carbonate, 35; fluorspar, 15; felspar, 30; barium carbonate, 25; potassium bichromate, 12; manganese, 7. *Blue aventurine:* Silica, 100; sodium carbonate, 35; fluorspar, 15; felspar, 30; barium carbonate, 25; potassium bichromate, 10; manganese, 5; cobalt oxide, ½. Pettenkofer and Hautefeuille devised receipts in which copper is used, the copper by slow cooling being thrown out in the glass pot as metallic spangles.

Porpora glass is an imitation of hematinone, a glass of a peculiar red colour found in Pompeii excavations. The colour is due to copper and iron. An imitation of hematinone was devised by Pettenkofer under the name of *astralite*.

Agate glass is obtained by melting together waste pieces of coloured glass.

Iridescent Glass. Iridescent glass, in imitation of ancient glass which has become iridescent through long exposure to damp, is made by exposing glass articles before annealing to the fumes generated by placing tin chloride alone or mixed with the nitrates of barium or strontium upon a hot plate in a muffle furnace. Wittmann's method is to boil the articles in hydrochloric acid under pressure, and Brianchon employed a flux of auriferous bismuth oxide.

Crackled Glass. Crackle, craquelé, or ice glass is made by plunging the freshly-blown glass article into hot water and reheating in the

furnace. A similar effect is obtained by sprinkling broken glass on the soft glass and reheating to incorporate the fragments. Satin glass is prepared by covering a vessel blown from coloured glass in which depressions have been formed with lead glass, while a beautiful matte silver appearance is obtained by covering unglazed porcelain with a layer of lead glass.

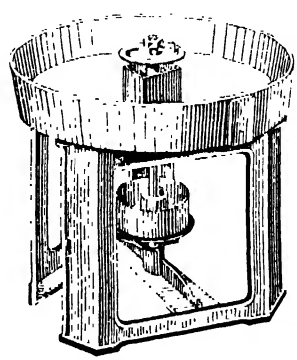
Glass Beads. Formerly Venice was the only place where glass beads were made, but factories now exist in France, Bohemia and Belgium. Glass of the required colour is drawn out into tubes. The work is executed by a foreman, who has under him two assistants and four workmen. One of the assistants dips the end of an iron rod about 4 ft. long into one of the glass pots. He then rolls it on an iron table to reduce it to a cylindrical form, and makes a round hole on the upper part of the mass. After this the foreman takes the rod in his hand and heats in the furnace the portion of glass attached to its end by giving it a few turns, taking care to see that the hole is exactly in the centre. He then attaches another rod to the upper part of the mass, the two rods are at once delivered to two workmen, who, running speedily in opposite directions, reduce the molten glass to a very long, thin tube. The glass tubes are then chopped up into small pieces, which are mixed with sand and wood ashes, transferred to an iron pot, and stirred till they begin to soften. The heat rounds the edges, and when cool the sand is sifted out and the beads finally polished with white bran.

Quartz Glass. A glass which stands excessive changes of temperature with indifference is made from Brazilian quartz. The quartz is used in lumps, but cannot be worked and melted directly, because it splinters. At 1,700° C. the crystalline quartz becomes vitreous, and tubes and vessels of quartz are built up in the heat of an oxyhydrogen blowpipe. Shenstone, the chief English worker in quartz, has devised a furnace for melting quartz by means of the electric arc and oxyhydrogen flame.

Water-glass. Silicate of soda or potash, made by fusing together sand and alkali, dissolves in water, and the product is known as *water-glass* or *soluble glass*. *Potash water-glass* is made by fusing together in a reverberatory furnace quartz sand 45 parts, potassium carbonate 30 parts, and powdered charcoal 3 parts. The mass is afterwards boiled with water to form a solution, in which state it is generally found in commerce. *Soda water-glass* is made with quartz sand 5 parts, sodium carbonate 23 parts, charcoal 3 parts, or with quartz 100 parts, sodium sulphate 60 parts, and charcoal 15 to 20 parts. *Double water-glass* is made with quartz sand 152 parts, sodium carbonate 54 parts, potassium carbonate 70 parts; or with quartz 100 parts, potassium carbonate 28 parts, sodium carbonate 22 parts, and charcoal 6 parts.

One of the earliest uses of water-glass was as an addition to soap, enabling more water to be taken up and a cheaper product to be obtained. For rendering fabrics non-inflammable they are dipped in a diluted solution of water-glass. Water-glass is also used as a preservative of wood and stone. Ransome's process for the production of artificial stone depends on the use of water-glass for binding together sand, the compressed bricks being soaked in a solution of calcium chloride to form an insoluble and thus permanent silicate of calcium. Fuchs devised a process of fresco-painting called *stereochromy*, in which the wall is prepared by the use of lime and water-glass, and the colours used in the painting are compounded with water-glass, with the object of increasing the permanence of the work. *Mineral glue* is the name applied to a cement consisting of water-glass. A large quantity of water-glass is now used for preserving eggs. The water-glass, as purchased, is diluted with water, and the eggs are laid in the solution, becoming covered with an impervious coating which excludes the air, and so keeps the eggs fresh for months. Water-glass is finding a use also in the alkali process of refining mineral oil.

Glass Decorating. The operation of cutting glass is particularly suited to *lead* glass, owing to the greater brilliancy of this kind of glass. The cutting operation consists of three stages: (1) Roughing out by means of an iron wheel; (2) cutting by means of a stone wheel; (3) polishing by means of a wheel of wood or cork [14]. The roughing-out wheel is supplied with sand to assist in the abrasion. A workman holds the article against the conical edge of a steel wheel secured to a shaft driven by belts and pulleys. Fine, sharp sand and water are allowed to drip on the wheel from a cone-shaped bucket. The article is pressed against the rapidly rotating wheel, and is deeply scored or cut. The heaviest and principal lines in the pattern are roughened in by these steel wheels. The roughened article is now ready for the wet smoothing-stone, which resembles the steel wheels both as to size and edge, but no sand is employed. These wheels follow the cuts made by the steel wheels, and also cut in the finer lines of the pattern. The practically finished article is now ready for the polishing, which is done by putty-powder or rouge-charged wooden wheels with the same sized edges as the previously used wheels. In place of wooden wheels felt-covered wheels or brushes are used; while the most recent method is to finish the polishing with hydrofluoric acid. The hydrofluoric acid is mixed with sulphuric and hydrochloric acid in about equal proportions, but the quantity of hydrofluoric acid is increased where a hard glass is



14. SELF-CONTAINED SMOOTHING AND POLISHING MACHINE
(G. G. Rider, Manchester)

being chemically polished. Fire polishing has also been applied to cut glass, but in this way the appearance is not much better than that given to fire-polished *pressed* glass. The iron wheels are known as *millers*. The stone wheels are mined in Yorkshire, Newcastle and Craigleith, the last-named producing the most esteemed variety. A new kind of wheel is sold under the name of *alundum*. The material of which these wheels are made is *bauxite*, which is fused in electric furnaces at Niagara Falls.

Glass Bevelling. The edges of glass plates are bevelled by cementing the glass upon a heavy horizontal bench, which, receiving a slow to-and-fro movement, presents the edges successively to the grinding action of one or more small grinders. Machinery has been devised to minimise the handwork. Like glass cutting, bevelling is done in stages with steel, stone and polishing wheels.

Etching Glass. Etching is accomplished by means of hydrofluoric acid, which acts on the silica of the glass to form silicon fluoride (a gas which escapes in the air) and water. Hydrofluoric acid alone is used, or a mixture of potassium acid fluoride 250 grammes, hydrochloric acid 250 grammes, and water 1 litre. A strong solution of ammonium fluoride acidified with hydrochloric or acetic acid is also used; while Henrivaux's receipt for etching fluid is calcium fluoride 250 grammes, hydrochloric acid 250 grammes, sulphate of soda 140 grammes, and water 1 litre. The parts of the glass which it is desired to protect from the etching fluid are covered with a varnish composed of yellow wax 4 parts and turpentine 1 part, but various other mixtures of gum, dammar, Venice turpentine, asphalt, resin, Burgundy pitch, and tallow are employed. Patterns are obtained by affixing tinfoil to the glass and cutting away the tinfoil at the parts to be etched. A quicker method is to print the pattern on the tinfoil in a grease pigment, and eat away the plain tinfoil with mineral acid to expose the glass, which is then treated with hydrofluoric acid.

Dry Etching. Dry etching is a process in which ammonium fluoride is used in the solid state. The design, which must be of comparatively small dimensions, is applied to the glass by printing thereon with printers' varnish from an indiarubber plate, or in any suitable way. While the impression is still moist some powdered ammonium fluoride, kept at a temperature of about 105° F., is applied to the surface with a soft brush, and caused by gentle pressure to adhere to the varnish, all superfluous salt being carefully removed. In about 15 to 60 minutes, according to the atmospheric humidity, the fluoride will have become liquid and have penetrated to and etched the glass underneath. The process is expedited by creating an artificial humidity in the atmosphere. The printing medium is prepared by mixing 70 parts of melted resin with 30 parts of olive oil, and colouring with dark-blue aniline dye. Glass is also etched by throwing against it a stream of sand or grains of quartz. The process was invented by Tilghman, in 1870, the abrasive effect of the sand being enforced by ejecting it with great force by a jet of steam or air. In engraving designs on glass, air is most convenient, as the sand, being dry, rebounds and leaves the pattern clear. Designs are etched by affixing to the glass a paper stencil. The paper is stuck on with glue, the parts to be etched being left clear. The method was improved, in 1877, by Mathewson, and a combination of the Tilghman and Mathewson apparatus is now generally employed. Sand blasting can also be employed for boring holes in glass, the blast being allowed to impinge on one spot. It should be added that the chemical method of etching by means of hydrofluoric acid gives a finer grain, but for many purposes the sand blast is preferred on account of its quickness.

Silvering Mirrors. Mirrors are prepared by depositing on smooth glass a coating of mercury or silver. The use of mercury has almost been abandoned on account of its injurious effect on the workmen. Drayton, in 1843, devised a process in which silver was deposited on glass from an alkaline solution of silver nitrate. The method was further investigated by Liebig, in 1867, and processes founded on Liebig's recipes have now replaced the older mercurial process. Two solutions are required, the silvering liquid and the reducing liquid. The *silvering* liquid is made as follows:

1. Dissolve 1 part of fused silver nitrate in 10 parts of distilled water.
2. Neutralise pure nitric acid with ammonium carbonate, and dilute it until the liquid has a specific gravity of 1·115, or dissolve 242 grammes of ammonium sulphate in sufficient water to make 1,200 c.c.
3. Prepare a soda solution of a specific gravity of 1·050.

Mix 140 volumes of solution No. 1, 100 volumes of No. 2, and 750 volumes of No. 3.

The *reducing* liquid is made as follows:

1. Make 50 grammes of white sugar candy into a thin syrup with water, and boil for an hour with 3·1 grammes of tartaric acid, diluting finally with water to make 500 c.c.
2. Moisten 2·857 grammes of dry tartrate of copper in water, and add caustic soda solution drop by drop until the blue powder is completely dissolved, and then dilute to 500 c.c.

Mix one volume of No. 1, one volume of No. 2, and eight volumes of water.

Fifty parts of the silvering liquid are poured into a shallow dish, and diluted with 250 to 300 volumes of water, and then 10 parts of the reducing liquid are added. In winter, warm water is employed, the temperature of the liquid being 20° C. to 28° C. The glass plate is put in and left for some hours, the silver being gradually precipitated on the surface of the glass.

Gilding and Platinising Glass. Glass is *gilded* by a somewhat analogous process, a dilute solution of sodium aurate being reduced by means of a saturated solution of ethylene in alcohol. In *platinising* glass, platinum is precipitated from its chloride by oil of lavender.

Continued

PROBLEMS IN CONES & CYLINDERS

The Ellipse. The Hyperbola. The Parabola. Envelopes of Cylinders. Sections of Joints. Developments of Oblique Cylinders

continued from page 4741

By JOSEPH G. HORNER

The Ellipse. Fig. 68 illustrates the development of an ellipse from a cone cut in the plane AA. Here it is necessary to have a half plan, or whole plan view, shown below, as well as an elevation.

Divide the base into any convenient number of equal parts 1, 2, 3, 4, 5, 6. Draw lines thence to the centre or apex in the plan view, and to the base in the elevation, and from the base to the apex *o*. From the points where the plane AA intersects the lines of division last drawn, and also from AA project lines down to the plan, cutting the lines of division there at *a, b, c, d, e, f, g*.

From these the actual dimensions of the surface in the plane AA are obtained on a centre line BB, parallel with AA. On BB erect perpendiculars from AA, starting from the successive points of intersection of AA, with the divisions projected up from the circular base. On these perpendiculars the widths of the ellipse are set off to right and left of BB; *bb, cc, dd, ee, ff*, corresponding to the dimensions of the distances from the centre plane *ag* of the section similarly lettered in the plan. Lines drawn through the successive points of intersection, B*bcdef*B, complete the ellipse.

An Alternative Method. Another method of obtaining the elliptical section of a cone is given in 69. Let AB be the plane of the section. Divide AB into any number of equal parts A, 1, 2, 3, 4, 5, B. Through these points draw horizontal lines B, 5*a*, 4*b*, 3*c*, 2*d*, 1*e*, A*f*. Obviously these will correspond with circle sections of the cone, and may therefore be projected as such to the plan below, and struck from the centre of the plan, cutting the line DD, as BB′, *aa′*, *bb′*, *cc′*, *dd′*, *ee′*, *ff′*. From the point A a vertical line is dropped, cutting DD at A′. So that A′ and B′ correspond in actual plan with the points A and B of the elliptical section of the cone. A′ also is tangent to the circle A*f*, projected down, and B′ also is tangent to the circle B, similarly projected. Similarly, perpendiculars projected from 1, 2, 3, 4, 5, give respectively *g, h, i, j, k* on the line DD; *g* cuts the circle *e′* at *ll*; *h* cuts the circle *d′* at *mm*; *i* cuts the circle *c′* at *nn*, and so on. If, now, the distances *gl*, *gl* are taken and transferred to 1*l′*, 1*l′* to right and left of the line CC above, and the distances *hm*, *hm* to 2*m′*, 2*m′* above, and so on, and a line drawn through the points of intersection, the ellipse will be produced, as shown.

The Envelope of the Ellipse. To obtain the envelope of a cone from which the surface has been cut elliptically [70, 71], proceed thus:

Strike a semicircle on the base AB of 70, and divide it equally at 1, 2, 3, 4, 5, 6, 7, B. Carry perpendiculars up to AB, cutting AB at D, E, F, etc., and prolong lines thence to the apex *o*. These will cut the diagonal CC at 1′, 2′, 3′, 4′ 5′, 6′, 7′. Thence carry horizontal lines along to cut the slant edge A*o* in *a, b, c, d, e, f, g*. The lengths A*a*, A*b*, A*c*, etc., will be the real lengths of the lines D1′, E2′, F3′, etc., since all are thus measured on the *slant* edge.

The envelope is shown in 71, to the right. With radius *o*A [70] strike an arc *o*AA [71]. To right and left of a centre line *o*B mark off the equal divisions in the plan of the cone 7, 6, 5, 4, 3, 2, 1, A, so completing the circumference of the base. Next, draw lines from all these points of division to the apex or centre *o*. On these lines the lengths just projected have to be marked thus:

Take the length BK [70], and set it off from B to K in 71. Take the length AL in 70 and mark it off at each end AL in 71. Take A*a* [70] and mark that off at 1*a*, 1*a* [71]. Take A*b*, and set that off at 2*b*, 2*b* [71], and so on. A line LKL drawn through all the successive intersections will give the envelope for the cone. Also, if the envelope for the upper portion—all above the part cut in section—were required, that would be given by the supplementary portion in 71 between LKL and the lines going to the apex *o*.

The seams of the plate are added along the edges AL, AL. The seam could be made along BK, but this would not affect the method of marking out, but only the starting centre-line AL, instead of B*k*.

The Hyperbola. Fig. 72 shows a cone cut CC, parallel with the axis, which yields the section of a hyperbola on the cut face. Strike a semicircle on the base AB, and prolong the plane CC to meet it at D. Divide the arc DB into any number of equal parts, as *a*, *b*, B, and raise them as perpendiculars to meet AB at *a′b′*, and draw lines thence to the apex *o*, cutting the plane CC in *c* and *d*. From *c* and *d* horizontal lines are carried out to cut *o*B at *c′ d′*.

For the envelope, take the radius *o*A [72], and strike the arc AA in 73. Taking a centre B, set off to right and left the distances B*b*, *ba*, *a*D, corresponding with B*b*, *ba*, *a*D in 72, and draw lines thence to the centre *o*. Set off B*e*, *bd′*, *ac′* [73], cutting B*o*, *bo*, *ao*, equal in length to B*e*, B*c′*, B*d′* on the slant of the cone in 72. The line D*e*D drawn through the points of intersection [73] is that of the outline of the hyperbolic surface cut away in 72.

For the envelope of the remainder of the cone, divide the arc AD [72] into any number of equal parts, A, *f*, *g*, *h*, *i*, D. With the same setting of the compass, set off distances from D [73] to right and left, D, *i*, *h*, *g*, *f*, A. Lines drawn from A to *o* and A to *o* will complete the figure required.

Shape of the Cut Face. These are developments of the cone. But to obtain a flat sheet to correspond with the cut section of the hyperbola proceed as in **74**.

Erect a perpendicular AB on a base line CD. Make AC, AD each equal in length to the width of half the base CD of the hyperbola in **72**. Make AB equal in height to the length of the major axis of the hyperbola, equal to the height CO in **72**, obtained by prolonging the plane of the section CC to intersect the slant height A*o* prolonged. Draw a horizontal [**74**] at a height AE equal to the height C*e* of the hyperbola in **72**. Next divide AC, AD [**74**] and the height CE each into the same number of equal parts—four in the example, more in a large pattern; 1, 2, 3, C, and 1′, 2′, 3′, E. Draw lines from 1, 2, 3, to the apex B, and from 1′, 2′, 3′, to the height E. A curve drawn through the points of intersection will give the shape of the hyperbola.

The Parabola. Fig. **75** shows a cone cut in parabolic section. The method adopted is like the previous one. The parabolic section is cut in the plane CC, parallel with the slant *o*B; and CD is projected perpendicularly to cut the semicircle AB below. The arc DB is divided equally *a*, *b*, B. DA is divided also, *h*, *i*, *j*, *k*, and lines are carried to *h*′, *i*′, *j*′, *k*′. The points of division outside the parabolic section are projected from the line AB to the apex *o*, and the plane of the parabola intersects them at *c*, *d*, *e*, *f*.

For the development, the radius *o*B is taken, and an arc BB struck with it [**76**], and a middle line of division *o*A taken. From this arc set off to right and left the divisions taken from A, *h*, *i*, *j*, *k*, D [**75**], and lines drawn thence to the centre *o*. Measurement is taken from A to *g* [**75**], and transferred from A to *g* [**76**]. Next, from A to *f*′ [**75**], and transferred from *h* to *f* [**76**], then from A to *e*′, transferred from *i* to *e*, and so on to each side of the centre A, completing by their intersection with the radial lines the points in the developed parabolic outline. Then, from DB [**75**], the divisions D*a*, *b*B, are taken and transferred to **76**, and the end lines B*o*, B*o* drawn.

To obtain the outline of the plane parabolic section [**77**], draw a base AB the length of each half CA, CB being equal to the dimension CD in **75**. Erect a perpendicular CD equal to the length CC in **75**. Divide half the base and the total height into the same number of equal parts. Erect perpendiculars from the base, and diagonals from the sides, meeting at D. Draw the parabola through the points of intersection.

Arc and Chord Divisions. The difference between arc and chord measurements as they affect the length of a curved envelope is shown in **78** and **79**, which are semicircles, both divided with chord measurements, but in **78** the divisions taken are longer than in **79**; the difference is apparent in the lengths *ab* in the two illustrations.

Envelopes of Cylinders. To develop the envelope of a cylinder jointing up against another similar cylinder with a mitre joint, proceed thus [**80**, **81**]. In **80**, the cylinder A, the envelope of which is desired, has its circular base projected in plan below for the purpose of obtaining points of equal division on the circumference as convenient, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10. These are projected up to the elevation, cutting the plane of the joint *ab* in *a*, 1′, 2′, 3′, etc. From these points of intersection horizontal lines are carried along to **81**, as shown. Also, a horizontal line *oo* [**81**] is carried in continuation of the base *cd* of the cylinder A in **80**. Now make the length *oo* equal to the circumference corresponding with *cd*, either by multiplying the diameter *cd* by 3·14159, or by taking the points of equal division, 0, 1, 2, 3, 4, etc., in **80**, and repeating them twice over in **81**, as shown.

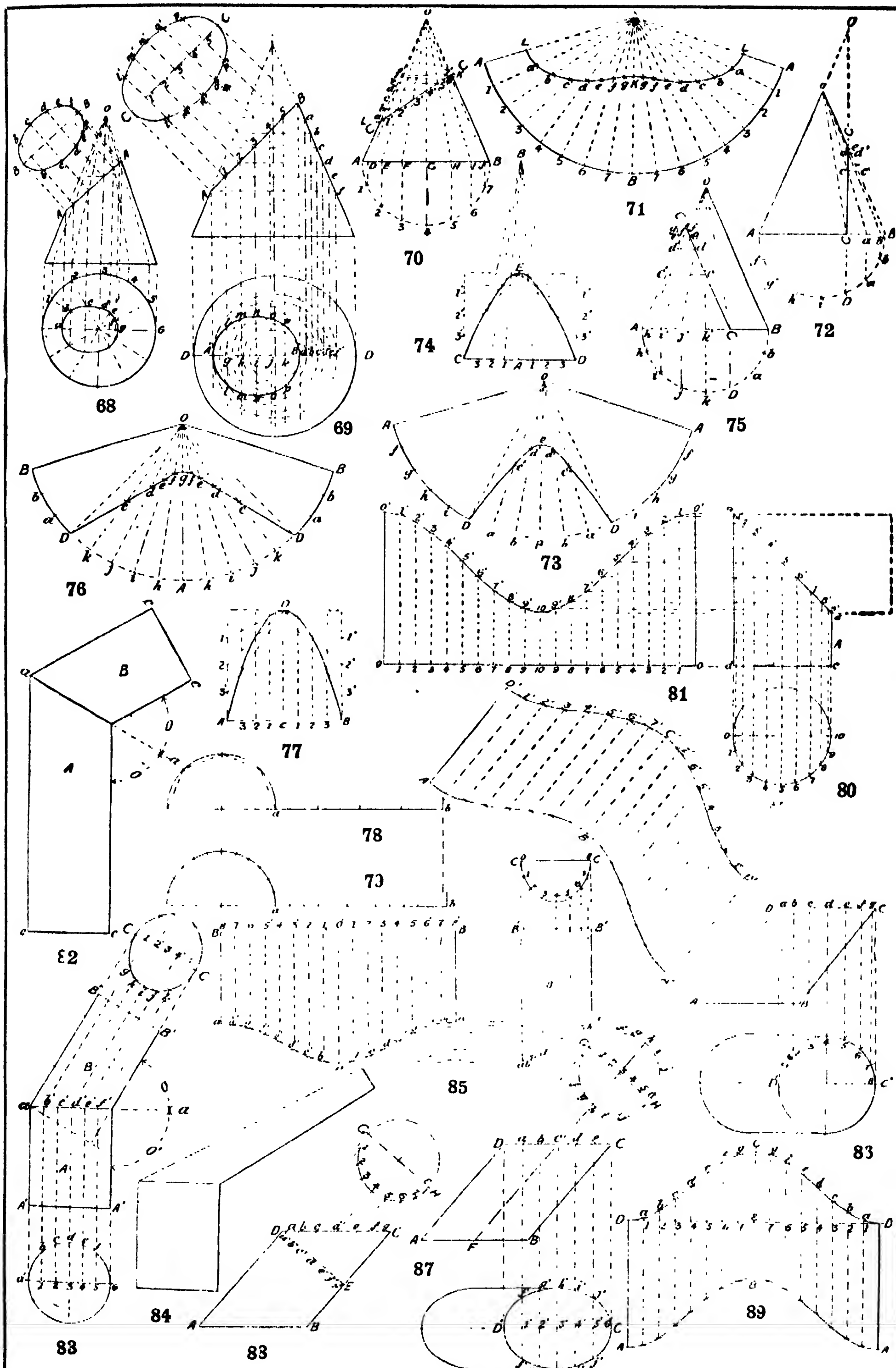
Raise perpendiculars in **81** from 0, 1, 2, 3, 4, etc., until they intersect the horizontal lines *a*, 1′, 2′, 3′, 4′, 5′, etc., previously drawn. If, now, in **81** a curve is delineated through the points of intersection of horizontals and verticals *o*′, 1′, 2′, 3′, 4′, etc., that will be the developed edge of the joint. This curve, with the horizontal *oo* and the verticals *oo*′, *oo*′, complete the envelope for the cylinder A.

Sections of Cylinders. The great advantage of exaggerating a doubtful figure is now applied to sections of cylinders. If we take two cases [**82**, **83**], we have in one [**82**] two circular cylinders; in the other [**83**] one circular and one elliptical cylinder united.

Equal Angles. In **82**, since the jointing plane *aa* of the two cylinders bisects the angle formed by the edges (or centre lines) of the cylinders, so that the angles *o*, *o* are alike, the cylinders A and B must be alike in their sections on the plane *aa*, and also at the ends *cc*. Such cylinders may have circular, or elliptical joints or ends. But if the ends *cc* (and bodies) are cylindrical, then it is clear that along the joint *aa*, both alike must be elliptical. And if they are of circular shape on the plane *aa*, then at *cc* they must be elliptical, and the shorter axis of the ellipse must be from *c* to *c*. These points are illustrated further in **83**.

Unequal Angles. Here, the jointing angle *aa* is not alike for A and B, but *o*′ is wider than *o*. It follows that, though A and B must be alike on the plane *aa* (for if otherwise they would not make a flush joint), they differ in section away from that joint, because it is impossible to joint two like bodies except at equal angles. If in **83** the cylinder A is of circular section, then B must be elliptical, and vice versâ.

In **83**, the plan of cylinder A is drawn below, that of B is drawn above, and the method by which its shape is found is as follows: As the joint *aa* is perpendicular to the sides of the cylinder A, and A is of circular section, we mark the circle *a*′6 below from A′A′. We divide its horizontal axis into any convenient number of equal parts 1, 2, 3, 4, 5, 6, and raise perpendiculars therefrom, cutting through the circumference at *b*, *c*, *d*, *e*, *f*, and thence to cut the joint *aa* at *b*′, *c*′, *d*′, *e*′, *f*′. Prolong lines from these points parallel with the axis of B to cut a line CC above, perpendicular to the axis of B, and having a length CC equal to the diameter B′B′ of B, the lines cutting it at 1′, 2′, 3′, 4′, 5′, as shown. On the circle below take the distance 1*b*, and set it off



SECTIONS AND ENVELOPES OF CONES AND CYLINDERS

68. Elliptical section of cone **69.** Another method of obtaining the elliptical section **70, 71.** Envelope of cone cut in elliptical section **72.** Hyperbolic section of cone **73.** Envelope of same **74.** Shape of cut portion **75.** Parabolic section of cone **76.** Envelope of same **77.** Shape of cut portion **78, 79.** Effects of chord measurement **80, 81.** Envelope of cylinder **82.** Jointing of cylinders at equal angles **83.** Jointing at unequal angles **84.** The same exaggerated **85.** Development of cylinder cut at an angle **86.** Development of oblique cylinder **87, 88, 89.** A similar development

from 1′ to g above. Take the distance 2e below, and set it off from 2′ to h above, and so on. A line drawn through C$ghijk$C will represent one half the true section of the cylinder B ; that is the shortest section corresponding with B′B′, or anywhere else parallel therewith.

Elliptical and Circular Sections. But we see now clearly that B is elliptical in real normal section, though in the plane aa it is circular. Also B′B′ is the minor or shorter diameter of the ellipse. This reveals itself too, because as A is circular, B must match A at the joint aa. Yet as B neither stands normally at the joint aa, nor with a common angle of joint, the effect of these conditions must be to shorten B along the lines aa and B′B′. B must be elliptical in section. but cutting it along aa produces a circular section there. Suppose A and B to be shown as in **84**, the facts just stated would be more obvious. It is also clear that if B were of circular section in **83**, A must be elliptical, but in this case the major diameter of the ellipse would be along aa.

Development of Cut Cylinders. The development of the portion B in **83** is shown in **85**. To avoid confusion of lines, the construction of B and its elliptical shape in the plane B′B′ [**83**] is transferred to **85**, whence a new set of divisions is obtained for the development, as follows :

Divide the semi-ellipse CC into any convenient number of equal parts, 0, 1, 2, 3, 4, 5, 6, 7, 8, and project lines from these points of division to cut the sloping joint face aa at b, c, d, e, f, g, h. Draw a line BB to the left, continuous with the plane B′B′, and make its length equal to the circumference of B by stepping along with compasses twice the number of divisions obtained in the half plan over the cylinder B, 0′, 1′, 2′, 3′, 4′, 5′, 6′, 7′, 8′, twice repeated, and draw lines therefrom perpendicular to the line BB. Carry horizontals along to cut these lines successively from a to a', b to b', c to c', etc. Through the points of intersection draw the curve shown, which, with the horizontal and vertical lines, will complete the envelope of the cylinder B.

Development of Oblique Cylinders. A method of drawing the envelope of this is shown in **86**. Let ABCD represent the cylinder in outline, the ends being circles, as shown in plan. Divide the latter into any convenient number of equal parts, 1, 2, 3, 4, 5, 6, 7, 8. Project these divisions to the upper plane to a, b, c, d, e, f, g, D and C being the boundaries. Draw lines D′A′ adjacent to DA, and parallel with DA. Draw lines, as shown, perpendicular to DA, and starting from D, a, b, c, d, e, f, g, C. Take one of the equal divisions 1, 2, 3, etc., from the plan with compasses, and, beginning at D′, set it off first to 1′, cutting the perpendicular from a. Then set off the same from 1′ to 2′ on the perpendicular from b, until the eighth division is reached at C′, after which the divisions are stepped down to 7′, 6′, 5′, etc., until D′ at the end of the pattern is reached. A line drawn through these points gives the outline corresponding with DC.

For the other edge, take the slant length DA and set it off on all the lines drawn perpendicularly to the line D′D′, and draw a line through the points of intersection. Then A′B′A′ will give the outline corresponding with the edge AB of the cylinder.

An Alternative Method. Another method of drawing the envelope of an oblique cylinder is shown in **87, 88** and **89**. The cylinder differs from **86** in being a circular one. If it were not circular, the method to be described would serve equally well.

In **87**, ABCD represents the oblique cylinder in elevation, and DE [**88**] is the plane cutting it at right angles with its axis. Prolong the sides AD, BC [**87**] and also the axis Fc upwards. Draw the line GH at any convenient distance from and parallel with DE, and meeting the prolonged lines AD, BC at GH. Divide GH into any number of equal parts 1, 2, 3, 4, 5, 6, and through 1, 2, 3, 4, 5 draw lines parallel with the axis Fc of the cylinder. Divide the axis in the plan view below, projected from the plane DC above to D′C′ below, into the same number of equal parts as GH above, 1′, 2′, 3′, 4′, 5′, 6′, and draw lines through these at right angles with D′C′, meeting the upper set of lines at a, b, c, d, e. The ellipse having D′C′ for its major axis may have been described by the method shown in a previous problem [**83**] by divisions round a semicircle. In **87** take the dimensions 1′f, 1′f on each side of D′C′, and set these off on each side of GH, at 1f, 1f, and repeat the operation for 2′g′, 3′h′, etc. A curve G$fghij$H$jihgf$G will represent the true section in the plane DE.

The Envelope of the Oblique Cylinder. To find the development of the envelope of **87**. The ends are ellipses, as shown in the lower part of the diagram. The cylindrical body is obtained as in **88** and **89**.

Fig. **88** is the upper portion of **87** repeated, but with new divisions. The circular plane is divided into any number of parts, eight on the semicircle, and lines are drawn from these parallel with the axis of the oblique cylinder, cutting DC at a, b, c, d, e, f, g, and prolonged to DE.

In **89**, draw a line DD equal in length to the circumference of DE in **88**, by setting round the equal divisions 1 to 8 twice. Draw lines through these points of division perpendicular to the line DD. Starting from D, and referring to **88**, take the distance aa' and set it off from 1 to a [**89**]. Take the distance bb', and set it off from 2 to b [**89**], and so on, starting from each end D, until at the centre the distance 8C is equal to CE in **88**. The curve drawn through D, a, b, c, etc., in **89** will give the development around the plane DC in **88**.

Now set off lengths on the vertical lines from D, a, b, c, etc., each equal to the lengths DA or CB in **88**. A curve ABA drawn through the points of intersection will give the development around the plane AB in **88**.

Continued

ITALIAN Continued from page 4791 By Francesco de Feo

IRREGULAR VERBS

Second Conjugation—continued

Verbs in **ere** (short)—continued

(*Past Def.* in *si*. *Past Part.* in *so* or *sto*.)

Intridere, to knead
Past Def.—*Intrisi, intrise, intrìsero.*
Past Part.—*Intriso.*

Invadere, to invade
Past Def.—*Invasi, invase, invàsero.*
Past Part.—*Invaso.*

Ledere, to offend
Past Def.—*Lesi, lese, lèsero.*
Past Part.—*Leso.*

Mordere, to bite
Past Def.—*Morsi, morse, mòrsero.*
Past Part.—*Morso.*

Nascondere, to hide
Past Def.—*Nascosi, nascose, nascòsero.*
Past Part.—*Nascosto.*

Perdere, to lose
Past Def.—*Perdei, perdetti, persi; perse, perdè, perdette; pèrsero* and *perdèttero.*
Past Part.—*Perso* and *perduto.*

Prendere, to take
Past Def.—*Presi, prese, prèsero.*
Past Part.—*Preso.*
Conjugate like *prèndere*: *intraprèndere,* to undertake; *sorprèndere,* to surprise.

Radere, to shave
Past Def.—*Rasi, rase, ràsero.*
Past Part.—*Raso.*

Rendere, to render
Past Def.—*Resi, rese, rèsero.*
Past Part.—*Reso.*
Conjugate like *rèndere*: *arrèndersi,* to surrender

Ridere, to laugh
Past Def.—*Risi, rise, rìsero.*
Past Part.—*Riso.*
Conjugate like *rìdere*; *arrìdere,* to favour; *derìdere,* to laugh at.

Rispondere, to answer
Past Def.—*Risposi, rispose, rispòsero.*
Past Part.—*Risposto.*
Conjugate like *rispòndere*: *corrispòndere,* to correspond.

Rodere, to gnaw
Past Def.—*Rosi, rose, ròsero.*
Past Part.—*Roso.*
Conjugate like *ròdere*; *corròdere,* to corrode.

Scendere, to go down
Past Def.—*Scesi, scese, scèsero.*
Past Part.—*sceso.*
Conjugate like *scèndere*; *accondiscèndere,* to yield.

Scindere, to separate
Past Def.—*Scissi, scisse, scìssero*
Past Part.—*Scisso.*
The compound *prescìndere* (to prescind) makes in the *Past Def.* *prescindei, prescindesti,* etc. *Prescìndere* has no *Past Part.*

Spendere, to spend
Past Def.—*Spesi, spese, spèsero.*
Past Part.—*Speso.*
Conjugate like *spèndere*; *sospèndere,* to suspend.

Tendere, to aim at, to display
Past Def.—*Tesi, tese, tèsero.*
Past Part.—*Teso.*
Conjugate like *tèndere*:

intèndere, to understand, to hear	*soprintèndere,* to superintend
estèndere, to extend	*contèndere,* to contend
pretèndere, to pretend	*stèndere,* to spread
protèndere, to stretch out	*sottintèndere,* to understand

Uccidere, to kill
Past Def.—*Uccisi, uccise, uccìsero.*
Past Part.—*Ucciso.*

Exercise XLV.

1. Il pòvero bambino è stato morso da un cane. 2. Ragazzi, dove avete nascosto il cappello di questo signore? 3. Abbiamo giocato e, secondo il sòlito, abbiamo perduto. 4. Chi ha preso il mio temperino? 5. Sono sorprèso della vostra condotta. 6. Fummo sorpresi alle spalle e dovemmo arrènderci. 7. Mi sorprende che non abbiate ancòra risposto alla mia lèttera. 8. Ho speso più di quello che avrei dovuto. 9. I lavori sono stati sospesi fino a nuov' òrdine. 10. Avete inteso la nuova opera di Puccini? 11. Vi ho dato due mesi di stipèndio. Non so cosa pretendete di più.

Esercizio di Lettura—continued

Viva e moia, son le parole che mandan fuori più volentieri; e chi è riuscito a persuadèrli che un tale non mèriti d'èssere squartato[1], non ha bisogno di spènder più parole per convincerli che sia degno d'esser portato in trionfo; attori, spettatori, strumenti, ostàcoli, secondo il vento[2]; pronti anche a star zitti, quando non sentan più grida da ripètere, a finirla[3], quando mànchino gli istigatori[4], a sbandarsi[5], quando molte voci concordi e non contradette àbbiano detto: andiamo; e a tornàrsene a casa, domandàndosi l'uno con l'altro: cos' è stato? Siccome però questa massa, avendo la maggiòr forza, la può dare a chi vuole, così ognuna delle due parti attive usa ogni arte per tirarla dalla sua[6], per impadronìrsene; sono quasi due anime nemiche, che combàttono per entrare in quel corpàccio, e farlo mòvere; fanno a chi saprà spàrger le voci più atte a eccitàr le passioni, dirìgere i movimenti a favore dell' uno o dell' altro intento; a chi saprà più a propòsito trovare le nuove[7] che riaccèndano gli sdegni, o li affievolìscano[8], risvèglino le speranze o i terrori; a chi saprà trovare il grido, che ripetuto dai più e più forte, esprima, attesti e crei nello stesso tempo il voto della pluralità, per l'una o per l'altra parte.

Notes. 1. To be quartered. 2. They are actors, etc., just as the wind happens to blow. 3. To give up. 4. When there is no one to prompt

them. 5. To become disbanded. 6. To draw it to their side. 7. To hit upon the news. 8. To weaken them.

THE ADVERB

Adverbs modify the meaning of verbs, adjectives, and other adverbs, as: *Costui parla troppo,* He talks too much; *Quella ragazza è molto bella,* That girl is very beautiful; *Lei parla l'Italiano molto correttamente,* You speak Italian very correctly.

The adverb may be used as a substantive, and very often also as an adjective. Examples: *Pensiamo all'oggi; al domani qualche santo provvederà,* Let us think of to-day; some saint will provide for to-morrow. *Un mestiere negli anni addietro assai lucroso,* a trade (that was) very lucrative in past years.

The adverb is invariable.

Adverbs are divided into several classes: adverbs of quality, manner, time, place, quantity, etc.

Adverbs of Quality

The adverbs of quality mostly modify verbs, and are formed by adding the substantive *mente* to the feminine singular of the adjective. Examples: *caro,* dear; *caramente,* dearly; *sincero,* sincere; *sinceramente,* sincerely.

The adjective is made feminine because it must agree with the substantive *mente,* which is feminine.

1. The adjectives ending in *-e,* being of both genders, of course do not change before the termination *mente.* Examples: *forte,* strong; *fortemente,* strongly; *decente,* decent; *decentemente,* decently; *diligente,* diligent; *diligentemente,* diligently. Observe, however, that the adjectives ending in *-le* and *-re* lose the final *e* if they are preceded by a vowel. Examples: *fedele,* faithful; *fedelmente,* faithfully; *fàcile,* easy; *facilmente,* easily; *particolare,* particular; *particolarmente,* particularly.

2. But if *-le* or *-re* are preceded by a consonant the *e* is retained. Examples: *folle,* foolish; *follemente,* foolishly; *acre,* harsh; *acremente,* harshly.

3. Of the adjectives in *-o, leggero,* light, drops the final *o,* and makes *leggermente.* The masculine singular of many adjectives may be used adverbially, as: *chiaro, chiaramente,* clearly; *forte, fortemente,* strongly, etc.

4. The adverbs admit of the same degrees of comparison as the adjectives from which they are formed. The superlative is formed by adding *mente* to the superlative feminine of the adjective. Examples: *fortemente* (strongly), comp., *più fortemente,* superl., *fortissimamente; elegantemente* (elegantly), comp., *più elegantemente,* superl., *elegantissimamente,* etc. Instead of the forms *fortissimamente, elegantissimamente,* etc., the periphrastic expressions *con molta forza, con molta eleganza,* etc. are often used. The superlative may also be expressed by the repetition of the adverb, as: *sùbito sùbito,* at once; *piano piano,* very slowly; *forte forte,* very strongly, etc.

5. To the adjectives with irregular comparatives and superlatives correspond irregular forms of adverbs. Examples: adjectives, *buono, migliore, òttimo;* adverbs, *bene, meglio, ottimamente,* and *benissimo.*

6. Some adverbs may also take diminutive and augmentative terminations, as: *benino, benone, adagino,* etc.

Key to Exercise XLIII.

1. See whether they have lighted the lamps in the dining-room. 2. What have you concluded? 3. They hoped to obtain who knows what, but they have been disappointed. 4. The strikers burned a large quantity of corn. 5. He asked me for some money, but I did not give it him. 6. Shut the windows, because a great storm is approaching. 7. To-day is a holiday, and all the shops are shut. 8. Everyone is running towards the church; who knows what has happened? 9. They decided to start at once, without waiting to hear from you. 10. She is offended because we have not returned her visit. 11. Italy was divided into so many small states. 12. The prisoner eluded the vigilance of the guards and succeeded in escaping. 13. The languages were confused.

Key to Exercise XLIV.

1. Be so kind as to tell me how this is said in English. 2. When we arrived in the church the service was already over. 3. Instead of standing here doing nothing, you had much better study your Italian lesson. 4. Have you heard from Mr. Charles? 5. No, we haven't heard any more of him; perhaps he is not in London. 6. Leave me alone, pray; I am in a bad temper to-day, without knowing why. 7. If you happen to see your friend, be so kind as to tell him to come to me this evening, because I have to speak to him. 8. I am sorry I cannot accompany you; I have to write some very important letters. 9. According to me, the hostilities will begin again in the spring. 10. What is the use of these tools? 11. Help yourself, sir; as you see, everything is ready. 12. What is the use of dwelling on the past? What is done is done.

Continued

FRENCH

Continued from page 4796

By Louis A. Barbé, B.A.

DEFECTIVE VERBS

The following verbs are used in some only of their tenses:

1. **Faillir,** to fail, to miss, to escape narrowly. *Past Part., failli,* from which all the compound tenses may be formed. In practice, the use of this verb is limited to the *Past Definite, je faillis,* etc., and the *Past Indefinite, j'ai failli,* etc. *Il a failli en mourir,* He was near dying of it.

2. **Défaillir,** to faint, to grow weak, is occasionally used in the plural of the *Ind. Pres.—nous défaillons, vous défaillez, ils défaillent.*

Imperf.—je défaillais. Past Def.—je défaillis.
Past Indef.—j'ai défailli.

3. **Férir,** to strike, is used in the single expression *sans coup férir,* without striking a blow.

4. **Gésir,** to lie, is used only in the *Present Participle—gisant.*

Ind. Pres.—il gît, nous gisons, vous gisez, ils gisent.

Imperf.—je gisais, etc.

Epitaphs frequently begin with *Ci-gît,* here lies—

Ci-gît ma femme. Ah, qu'elle est bien
Pour son repos et pour le mien.
Beneath this stone my wife doth lie;
Now she's at rest, and so am I.

5. **Ouïr,** to hear, is still occasionally used in the compound tenses, formed with the *Past Participle* —*ouï*. It is usually followed by *dire*—*j'ai ouï dire*, I have heard say. The old Imperative still subsists in the English criers' "O Yes!" corrupted from *oyez*. [See ENGLISH, page 1769.]

6. **Quérir,** to fetch, is occasionally used in the infinitive, instead of *chercher*, after *venir*, *aller* and *envoyer*.

7. **Saillir,** to project, *saillant*, *sailli*, can only be used in the third person singular or plural, and has no Past Definite—*il saille, ils saillent; il saillait*, etc., *il saillera*, etc., *il saillerait*, etc.

8. **Choir,** to fall: *Past Participle*—*chu*.

The Future *cherra* occurs in Perrault's "Fairy Tales."

9. **Déchoir,** to fall off, decay, *déchu*.

10. **Échoir,** to fall due, *échéant*, *échu*.

Ind. Pres.—*il échoit.* *Past Def.*—*il échut.*
Future—*il écherra.* *Cond. Pres.*—*il écherrait.*
Subj. Imperf.—*qu'il échût.*

11. **Seoir,** to become, to befit; *seyant.*
Ind. Pres.—*il sied, ils siéent.*
Imperf.—*il seyait, ils seyaient.*
Future—*il siéra, ils siéront.*
Cond. Pres.—*il siérait, ils siéraient.*
Subj. Pres.—*qu'il siée, qu'ils siéent.*

12. **Seoir,** to be situated, *séant*, *sis*, *sise*.

13. **Surseoir,** to put off, respite, *sursoyant*, *sursis*, is conjugated like the *oi*, *oy* form of *asseoir*—*je sursois*, etc., but has the Future and Conditional *je surseoirai* etc., *je surseoirais*, etc. It is used almost exclusively as a law term.

14. **Accroire,** to believe, is used only in the infinitive after *faire*, in the expression *faire accroire*, to make someone believe what is not true.

15. **Braire,** to bray.
Ind. Pres.—*il brait, ils braient.*
Future—*il braira, ils brairont.*
Condit.—*il brairait, ils brairaient.*

16. **Bruire,** to rustle, to murmur.
Ind. Pres.—*il bruit, (ils bruissent).*
Imperf.—*il bruissait, ils bruissaient*, and *il bruyait, ils bruyaient.*
Subj. Pres.—*qu'il bruisse.*

17. **Clore,** to close, *clos* is used in all its compound tenses, in the singular of the *Ind. Pres.*—*je clos, tu clos, il clôt*, and in all the persons of the *Future*—*je clorai*, etc.; *Cond.*—*je clorais*, etc.; and *Subj. Pres.*—*que je close*, etc.

18. **Éclore,** to be hatched, to open (of flowers), is used in the third person singular and plural of the same tenses, and of all the compound tenses, which are conjugated with *être*.

19. **Frire,** to fry, is commonly conjugated with the different tenses of *faire*, to make, *je fais frire*, I fry (make to fry). It may, however, be used in the singular of the *Ind. Pres.*—*je fris, tu fris, il frit;* throughout the whole of the *Future*—*je frirai*, etc.; the *Cond. Pres.*—*je frirais*, and in the *Imperat.*—second person singular—*fris*.

20. **Traire,** to milk, *trayant, trait, traite*, has no Past Definite.
Ind. Pres.—*je trais, tu trais, il trait, nous trayons, vous trayez, ils traient.*
Imperf.—*je trayais.* *Future*—*je trairai.*
Cond. Pres.—*je trairais*
Imperat.—*trais, qu'il traie, trayons, trayez, qu'ils traient.*
Subj. Pres.—*que je traie, que tu traies, qu'il traie, que nous trayions, que vous trayiez, qu'ils traient.*

Abstraire, to abstract, *distraire*, to divert, distract, *se distraire*, to amuse oneself, *extraire*, to extract, *soustraire*, to subtract, and *se soustraire* (*à*), to escape from, are conjugated like *traire*.

EXERCISE XXXV.

VOCABULARY

un arsenal, arsenal	*déplaire*, displease
une aventure, adventure	*descendre*, go down
le bout, end	*déterminer*, determine
le bruit, noise	*échapper (s')*, escape
le camarade, comrade	*écouter*, listen
le chapon, capon	*égarer*, lead astray
le charbonnier, charcoal-burner	*emporter*, to carry away, take away
le chemin, road	*entrer*, enter
le chevet, head (of a bed)	*étendre*, to stretch
la couronne, crown	*...iller*, awaken
le couteau, knife	*examiner*, examine
le coutelas, cutlass	*hurler*, howl
le déjeuner, breakfast	*inviter*, invite
le diamant, diamond	*laisser*, leave
le dogue, mastiff	*marcher*, walk
un escalier, staircase	*monter*, come up
la fente, chink	*omettre*, omit
le feu, fire	*oser*, dare
le fusil, gun	*passer (se)*, pass by, go by
la gorge, throat	*pendre*, hang
une hésitation, hesitation	*perdre*, lose, undo
un hôte, host	*poser*, lay down
une hôtesse, hostess	*prier*, request, beg
le jambon, ham	*promettre*, promise
la lampe, lamp	*raconter*, relate
le lendemain, next day	*rassurer (se)*, regain confidence
le lieu, the place	
la mine, appearance, look	*respirer*, breathe
le mot, word	*rester*, remain
la peine, difficulty	*retirer (se)*, retire
le pistolet, pistol	*saisir*, seize
le plafond, ceiling	*trouver*, find
sabre, sword	*tuer*, kill
sens, sense, meaning	*veiller*, watch
sentier, path	*voyager*, travel
	ne pas se faire prier, to require no pressing
...ouper, upper	
...oupçon, suspicion	
la tranche, slice	*à peine*, scarcely
le traversin, bolster	*au contraire*, on the contrary
la valise, valise	
le voyageur, traveller	*au dessous de*, beneath
	auprès, near
haut, upper (after noun)	*aussitôt*, immediately
malheureux, unhappy	*autrement*, otherwise
montagneux, hilly, mountainous	*dehors*, outside
	dès que, as soon as
pieds nus, barefooted	*devant*, in front, ahead
practicable, practicable	*doucement*, gently
...ux, precious	*du moins*, at least
riche,	*en bas*, below, downstairs
	eh bien! well
arriver, to arrive, happen	*enfin*, at length, now, finally
causer, to chat	
chercher, to seek, look for	*près de*, near to
comprendre, to understand	*tant que*, as long as
	tranquillement, quietly
consister, to consist	*voyons!* let us see, let us settle
coucher, lie down, sleep	
découvrir, uncover	

TRANSLATE INTO FRENCH

In a letter to his cousin a French writer, Paul Louis Courier, relates a terrible adventure which

happened to him in Italy (*Italie*). He was travelling in Calabria (*Calabre*) with a friend. It is a hilly country, and the horses of the two travellers walked with much difficulty. It was Courier's comrade who was going on ahead. He saw a path which seemed to him more practicable and shorter, took it, and led them astray. As long as it was (made) day they looked for their road; but the more they sought, the more they lost themselves, and it was black night when they arrived near (to) a very black house. They entered it (*y*), not without suspicion, and only because they could not do otherwise. There they find a whole family of charcoal-burners at table, to which (*où*) the two travellers were immediately invited. "My young man did not require to be pressed," says Courier. "There we were eating and drinking —he, at least; for as to (*pour*) me, I was examining the place and the appearance of our hosts. Our hosts had, indeed (*bien*), the looks of charcoal-burners; but the house—you would have taken it for an arsenal. There was nothing but (*ce n'étaient que*) guns, pistols, swords, knives, cutlasses." All this displeased him, and he saw plainly (*bien*) that he was displeasing too. His comrade, on the contrary, was (one) of the family; he laughed, he chatted, he said whence he came, where he was going, who he was. To (*pour*) omit nothing that (of what) could undo him, he played the rich (man), promised the charcoal-burners all they wanted to serve (to) him as guides next day. Finally, he spoke of his valise, begged them to take great care of it and to put it at the head of his bed. He did not want, he said, any other bolster. The charcoal-burners must have thought (believed) that he was carrying the crown diamonds. When the supper was finished, the hosts went down and left the travellers, who were to sleep in the upper room where they (*on*) had eaten. The younger of the two lay down without the least hesitation (with) his head on the precious valise. The other, determined to watch, made a good fire, and sat near (it). The night passed quietly, and he was beginning to regain confidence, when about the hour when (*où*) it seemed to him that the day(light) could not be far, he heard someone speaking beneath him. He listened. It was the charcoal-burner, who was saying to his wife: "Well, now, let us settle; must I kill them both?" The unhappy traveller remained scarcely breathing; to see him, one would not have known whether he was dead or alive (living). He dared not call or make any noise; he could not escape all alone. The window was not very high, but below there were two mastiffs, which were howling like wolves. At the end of a quarter of an hour, which seemed to him very long, he heard someone on the staircase, and through the chinks of the door he saw the father, (with) his lamp in one hand, in the other one of his big knives. The charcoal-burner came up, his wife after him. He opened the door; but before entering he laid down the lamp, which his wife came and took; then he entered barefooted, and she from outside said to him: "Gently, go gently." When he had come near the bed where the poor young man was stretched, offering his uncovered throat, with (*de*) one hand he raised his knife and with the other—he seized a ham which was hanging from the ceiling, cut a slice of it, and retired as he had come. As soon as day(light) appeared, all the family, with (*à*) great noise came and awakened the travellers. A very clean and very good breakfast was served. It consisted of two capons, of which they must, said the hostess, take one away (with them) and eat the other. On (*en*) seeing them, Courier understood, at length, the meaning of those terrible words: "Must I kill them both?"

Key to Exercise XXXIV.

1. La petite Marie, assise dans un fauteuil, lisait l'histoire du Petit Chaperon Rouge.
2. Quand la pauvre fille avait fait son ouvrage, elle allait s'asseoir dans les cendres, c'est pourquoi on l'appelait Cendrillon.
3. Ne vous asseyez pas sur l'herbe, elle est humide; vous vous enrhumeriez.
4. Il parlait à chaque instant de s'en aller, mais il se rasseyait toujours, et nous ne pouvions (pas) nous débarrasser de lui.
5. Pour émouvoir ses auditeurs il faut que l'orateur soit ému lui même; on n'émeut pas sans être ému.
6. Une armée est un corps animé d'une infinité de passions différentes qu'un homme habile fait mouvoir pour la défense de la patrie.
7. Lorsqu'on ne peut faire ce que l'on veut, il faut essayer de vouloir ce que l'on peut.
8. Nous parlons peu quand la vanité ne nous fait pas parler.
9. Nous oublions aisément nos fautes, lorsqu'elles ne sont sues que de nous.
10. La parfaite valeur est de faire sans témoins ce qu'on serait capable de faire devant tout le monde.
11. Les personnes faibles ne peuvent être sincères.
12. Nous sommes plus près d'aimer ceux qui nous haïssent, que ceux qui nous aiment plus que nous ne voulons.
13. Un philosophe a dit que peu de gens savent être vieux.
14. La vanité nous fait faire plus de choses contre notre goût que la raison.
15. Ce que nous savons est peu de chose en comparaison de ce que nous ne savons pas; et quelquefois même ce que nous ne savons pas est justement ce que nous devrions savoir.
16. Savoir qu'on ne sait rien, c'est savoir beaucoup.
17. L'homme qui se vend est toujours payé plus qu'il ne vaut.
18. Les grandes pensées viennent du cœur.
19. Le proverbe nous dit que tout vient à point à qui sait attendre.
20. Nous disons du bien de nos amis pour deux raisons; d'abord pour qu'ils apprennent que nous disons du bien d'eux, et ensuite pour qu'ils disent du bien de nous.
21. Ce qu'une judicieuse prévoyance n'a pu mettre dans l'esprit des hommes, une maîtresse plus impérieuse, je veux dire l'expérience, les a forcés de le croire.
22. Dites-nous ce qu'il faut faire et nous le ferons immédiatement.

Continued

SPANISH

By Amalia de Alberti & H. S. Duncan

ADVERBS

Adverbs are simple, derivative, or compound. They qualify nouns, verbs, or other adverbs, and denote time, place, manner, quantity, affirmation, negation, or doubt.

Simple adverbs consist of a single word, as *pronto*, soon; *luego*, directly.

Derivative adverbs are formed by adding *mente* to adjectives, according to the following rules.

Formation of Derivative Adverbs

1. With adjectives ending in *o*, *mente* is affixed to the feminine form. Example:

cierto, certain	*ciertamente*, certainly
orgulloso, proud	*orgullosamente*, proudly

2. With adjectives having one ending for both genders *mente* is simply added to the ordinary termination. Example:

feliz, happy	*felizmente*, happily
prudente, prudent	*prudentemente*, prudently
cortés, courteous	*cortésmente*, courteously.

3. *Mente* can never be added to adjectives not ending in *o* which have a feminine form, as *traidor, traidora*, treacherous. These can only be used adverbially with the phrase *de una manera*.

Example: *De una manera traidora*, treacherously, or, in a treacherous manner.

4. Most adverbs in *mente* can be turned into an adverbial phrase in this way if they denote manner.

Example: *Prudentemente*, prudently, or, *de una manera prudente*, in a prudent manner.

5. These adverbs can also be replaced by the preposition *con* and a noun. Example: *Con prudencia*, with prudence.

When several adverbs follow each other in a sentence, *mente* is only added to the last.

Example: *Franca, justa y claramente*, frankly, justly, and clearly.

Compound Adverbs. Compound adverbs are adverbial expressions composed of two or more words. Examples:

de golpe, suddenly	*á veces*, sometimes
de nuevo, anew	*á menudo*, often
de propósito, purposely	*en lo sucesivo*, henceforward
á porfía, persistently	*con todo*, notwithstanding

Adverbs of Time

cuando, when	*temprano*, early
ahora, now	*tarde*, late
entonces, then	*antes*, before
ayer, yesterday	*despues*, afterwards
hoy, to-day	*yá*, already
mañana, to-morrow	*todavia*, still
siempre, for ever, always	*nunca*, never

The adverb of time, *recientemente*, recently, is shortened to *recien* before a participial adjective. Example:

Murió recientemente, He died recently.
Los recien casados, The newly-married couple.
El niño recien nacido, The new-born child.

Adverbs of Place

aqui, here	*encima*, above
alli, ahi, there	*debajo*, beneath
acá, hither	*cerca*, near
allá, thither	*lejos*, far
adelante, forward	*adentro*, inwardly
donde, where	*dentro*, within
atrás, backward	*fuera, afuera*, without
arriba, up	*enfrente*, opposite
abajo, down	*junto*, near, next to

1. *Aqui* and *alli* are used with verbs of rest, *acá* and *allá* with verbs of action, and *ahi* with either.

2. *Aqui* and *acá* denote the place where the speaker is, *ahi* the place where the person addressed is. *alli* and *allá* some other place remote from both.

3. The meaning of *donde* is specialised by prepositions. *¿ A dónde van ?* Where are they going ? *¿ Por dónde pasa ?* Which way does he go ? *La ciudad en donde nació*, The city where (or in which) he was born.

Donde assumes an accent when interrogative.

Adverbs of Manner

como, how	*recio*, strongly, rapidly
asi, so	*quédo*, softly, gently
bien, well	*casi*, nearly, almost
mal, badly	*casi casi*, very nearly
alto, aloud	*mejor*, better
bajo, low	*peor*, worse

Most adverbs in *mente* are also adverbs of manner.

Adverbs of Quality

cuanto, how much	*demasiado*, too, too much
mucho, much	*más*, more
muy, very	*harto*, sufficiently
poco, little	*algo*, somewhat
bastante, enough	*como*, how, as
apénas, scarcely, hardly	*además*, besides

1. Care must be taken in the use of *muy* and *mucho*. The English "very much" cannot be translated "*muy mucho*," but must be rendered by the superlative of *mucho*—*i.e.*, *muchisimo*.

2. *Muy* qualifies adjectives, adverbs, and adverbial phrases. It can never stand alone, but is replaced by *mucho*. Examples:

Es muy rico, He is very rich. *¿ Es muy rico ? Si mucho*, Is he very rich ? Yes, very.

Estuvo muy enfermo, pero está muchisimo mejor, He was very ill, but he is very much better.

Adverbs of Affirmation, Negation, and Doubt

sí, yes	*acaso* }
no, no	*talvez* } perhaps
nunca, never	*quizás* }
jamás, ever, never	*apénas*, hardly
siempre, always	*probablemente*, probably
por cierto, certainly	*dificilmente*, improbably
por supuesto, of course	*ya no*, not now; no more
nada, not at all	

1. With some verbs *sí*, yes, requires the conjunction *que*, that. Examples: *Digo que sí*, I say "yes." *Temo que no*, I fear not. *Creo que sí*, I believe so.

2. The negative terms *nunca* and *jamás* may be used together to emphasise a negative, and should be translated "never again." Example: *No le escribiré nunca jamás*, I will never write to him again.

3. When the negative terms *ni*, neither, nor; *ninguno*, none; *nunca, jamás*, never; *nada*, nothing, follow the verb, *no* is required, but not when they precede it. Examples:

No quiero nada } I want nothing
Nada quiero }
No tengo ni vino ni agua } I have neither wine nor
Ni vino ni agua tengo } water.

Degrees of Comparison

Adverbs form their degrees of comparison like adjectives, but without variation in gender and number.

POSITIVE—*Claro*, clearly; *cerca*, near.

COMPARATIVE—*Mas claro*, more clearly; *mas cerca*, nearer.

RELATIVE SUPERLATIVE—(*Lo*) *mas claro*, the most clearly; (*lo*) *mas cerca*, the nearest

ABSOLUTE SUPERLATIVE—*Clarísimo*, very clearly; *cerquisimo*, very near.

1. The article is not used with the relative superlative in the case of adverbs, but the sense plainly shows whether this or the comparative is intended.

2. The absolute superlative of adverbs in *mente* is formed by changing the adjective superlative *isimo* into *isimamente*. Examples:

Doctamente, learnedly, *doctisimamente*, very learnedly.

3. The forms of comparison are: *Mas felizmente que*, more happily than; *menos felizmente que*, less happily than; *tan felizmente como*, as happily as.

4. The following adverbs form their degrees of comparison irregularly.

POSITIVE—*Mucho*, much; *poco*, little; *bien*, well; *mal*, badly.

COMPARATIVE—*Mas*, more; *menos*, less; *mejor*, better; *peor*, worse.

RELATIVE SUPERLATIVE—(*Lo*) *mas*, the most; (*lo*) *menos*, the least; (*lo*) *mejor*, the best; (*lo*) *peor*, the worst.

ABSOLUTE SUPERLATIVE—*Muchisímo*, very much; *poquisímo*, very little; *malisímo*, very badly.

Adverbial Phrases

á la clara, openly, manifestly
á la larga, in the long run
á la ligera, lightly, superficially
al momento, instantly, at once
por lo más, at most
por lo menos, at least
de buena gana, willingly
de todo punto, wholly
en seguida, directly, presently
á ciegas, blindly
por si acáso, in case
ahora mismo, this very moment
muy á la moda, very fashionably
al revés, on the contrary, quite the opposite
de revés, from left to right
muy de prisa, in great haste
camino adelante, onward
años atrás, years ago, long ago
cuesta arriba, uphill
á mas correr, at full speed
á mas no poder, with all one's might
cuanto antes, as soon as possible
de cuando en cuando } now and then
de vez en cuando }
de parte á parte, through and through
hoy dia, nowadays
tanto mas ó menos, so much more or less
tanto mejor, so much the better
tanto peor, so much the worse
entretanto, in the meantime
algun tanto, a little
tanto me gusta, I like it so much
por tanto, therefore

EXERCISE XIX. (1)

Translate the following into Spanish:

1. It is certain that his conduct gave proof of valour. Certainly nobody would have believed it.

2. He proudly refused the reward offered him; in this case his pride was just.

3. He was very pleased with the present they made him. Was he pleased? Very pleased.

4. Very many people thronged to see the procession.

[Do not use the superlative; it would be sufficient to say, many people thronged.]

5. He was always lazy, and he will never correct himself of this fault. Let us not lose hope: perhaps with age he will correct it. Perhaps it may be so, but I fear not.

6. He gave proof of being prudent in withdrawing from the contest. I should say he prudently withdrew, as his disadvantage was clear.

7. I do not deny that he is courteous, but he is not an agreeable person, and I should like to bid him farewell courteously.

8. Our friend died recently, and also the newborn baby.

EXERCISE XIX. (2)

Translate the following into English:

1. Feliz es el que pasa una vida tranquila sin grandes acontecimientos, muchos tienen la dicha de que esto les suceda.

2. Apénas hubo heredado una gran fortuna, la derrochó.

3. Probablemente el público nos prodigará sus alabanzas cuando sepa lo que hemos hecho, sin comprender los motivos que nos impelieron.

4. Nuestro amigo se acuesta temprano y se levanta tarde.

5. De arriba abajo, dentro y fuera, de aqui, alli, sin cesár todo el día, hasta que nos cansámos de verlo, y cerrámos la puerta, y temo que jamás nos perdone la afrenta.

6. Doctamente nos hizo un discurso, explicándonos varios asuntos doctisimamente expuestos, pero sumamente fastidiosos.

7. Dió poco mas ó menos todo lo que poseía á los pobres y esto era poquísimo; de buena gana hubiera yo añadido algo, pero temí ofenderle.

8. El cuarto se llenó de humo, y á ciegas busqué la puerta.

9. Al momento que le vi le conocí, y de seguída le hablé.

PROSE EXTRACT XV.

From "Notas sobre el Comercio Hispano-Británico en el año 1904."

The problem of transport is of vital importance for Spain, and, until it is solved, it is useless to think of the mercantile and industrial development of the Peninsula. Very special attention has been and is being devoted to this subject abroad. In the United States, for example, one of the reasons which has made possible the extraordinary development of the metal industry, apart from the possession of abundant iron ore and coal mines, is found in the great facilities and economy of their excellent system of communication, not only by rail, but also by sea and river, which shortens the distances to an amazing extent between the mineral-producing centres and the coalfields, it being almost incredible in Spain that in the principal centres of the metal industry in the United States, such as Pittsburg, Chicago, Youngstown, and Weeling, the mineral and the fuel employed are sometimes separated one from another by a distance of 800 to 1,000 miles. The deficiency of Spain, as regards this important question of railways, is most clearly shown up if we consider that the Peninsula, with a territory of 404,000 square kilometres in extent, has only 13,000 kilometres of

El problema de transportes es de vital importancia para España, y, mientras no se resuelva, es inútil pensar en el desarrollo mercantil é industrial de la Península. En el extranjero, se ha prestado y presta á dicho asunto especialisima atención. En los Estados Unidos, por ejemplo, una de las razones que ha hecho posible el extraordinario desarrollo adquirido por la industria metalúrgica está, aparte de la posesión de abundante mineral de hierro y de minas de carbón, en las grandes facilidades y economía del excelente sistema de transportes, tanto férreos como marítimos y fluviales, que permite acortar las distancias de un modo asombroso entre los centros productores de mineral y los yacimientos de carbón, siendo casi inconcebible en España el que en centros principales de la industria metalúrgica de los Estados Unidos, tales como Pittsburg, Chicago, Youngstown y Weeling, el mineral y el combustible empleado hállanse á veces separado uno de otro por una distancia de 800 á 1,000 millas. La deficiencia de España, respecto á esta importante cuestión de vías férreas, aparece con toda evidencia si pensamos que la Península, con un territorio de 404,000 kiló-

railway, while Great Britain, with a smaller area—*viz.*, 314,000 square kilometres, has a network of railways of nearly 40,000 kilometres.	metros cuadrados de extensión, cuenta solamente con 13,000 kilómetros de ferrocarriles, mientras que la Gran Bretaña, con un territorio menor, ó sea de 314,000 kilómetros cuadrados, tiene una red de caminos de hierro de cerca de 40,000 kilómetros.
It is true that the geological formation of the Peninsula renders the construction of such communication very difficult and extremely costly, as the average cost of the railway per kilometre in the mountainous districts of Spain is between 120,000 and 150,000 pesetas. For this reason we do not found any great hopes on the light railway scheme recently promulgated, because the guarantee of 4 per cent. on the basis of a capitalisation of 50,000 pesetas per kilometre is insufficient for the greater part of the proposed lines.	Es cierto que la constitución geológica de la Península dificulta mucho la obra de las comunicaciones y la hace sumamente costosa, pues el coste medio por kilómetro de los ferrocarriles en los distritos montañosos de España asciende de 120,000 á 150,000 pesetas próximamente. Por esta razón no fundamos grandes esperanzas en la ley de ferrocarriles secundarios promulgada últimamente, porque la garantía de 4°/ₒ, sobre la base de una capitalización de 50,000 pesetas por kilómetro, es insuficiente para la mayor parte de las líneas proyectadas.

Key to Exercise XVIII. (1)

1. No se puede decir " De esta agua no beberé."
2. Vamos esta noche al teatro. Irémo [illegible] och
3. Maldiciendo su suerte, se suicidó.
4. Bendigamos la providencia por sus beneficios.
5. Oigamos el buen consejo que nos es dado, y despues de oído sigámoslo.
6. Venid cuando el deber os llama, y al hacerlo (doing so) regocijarse.
7. El mundo nos ha absuelto de toda culpa.
8. El hijo de la Señora de T. está deformado.
9. Un déspota oprime á los que lo rodean, pero oprimiendo se hace aborrecer.
10. Prendieron al asesino. Fué preso despues de ofrecer mucha resistencia.
11. Hay una tienda que se dice ser " proveedor general." Ha provisto á muchos desde la cuna hasta la sepultura.
12. Se ha roto mi reloj, y el criado rompió el vaso despues de romper la fuente.

Key to Exercise XVIII. (2)

1. Old chests are found in Holland, carved with great skill, which are much prized.
2. Cupid's quiver is full of treacherous arrows.
3. I went to the florist and bought choice and sweet-smelling flowers.
4. The cat scratched me with its claws.
5. The art of spinning has gone out of fashion. In olden times even queens spun, and with the thread produced by their wheels they wove very fine linen.
6. That man thinks himself a first-class writer, and he is so illiterate that all his quotations are incorrect.
7. To inflame the evil passions of our neighbour is an infamy.
8. Moss, ferns, and wild grass are found on mountain sides.
9. Sometimes pebbles of a certain value are found in the sand on the seashore.
10. We put the apples and pears to ripen.

Continued

ESPERANTO

By Harald Clegg

PRONOUNS

Possessive Pronouns. These are formed from the personal pronouns simply by the addition of *a*. *Mia*, my, mine; *via*, your, yours; *ilia*, their, theirs, etc. Being adjectival, they follow the general rule of taking *j* for the plural, and *n* for the accusative. The only pronoun which does not submit itself to any of the above changes is *oni*. It is always used in the nominative case. In translating the English words, mine, yours, theirs, and so on, the article may, if preferred, be employed. Examples:

Mi havas viajn librojn, kaj vi havas (la) miajn, I have your books and you have mine. *Ŝia filo frapis (la) mian*, Her son struck mine.

Viaj amikoj estas malbonaj, la miaj estas bonaj, Your friends are bad, mine are good.

Reflexive Pronouns. The pronouns, *sia*, *sian*, *siajn*, formed from *si*, will demand careful attention, and as they are dealt with fully in another lesson, the exercises at the end of this lesson will avoid their use.

NUMERALS

Cardinal Numbers. These are *unu* (1), *du* (2), *tri* (3), *kvar* (4), *kvin* (5), *ses* (6), *sep* (7), *ok* (8), *nau* (9), *dek* (10), *cent* (100), *mil* (1,000), which, being root words, are invariable. *Nulo* represents 0, and being a noun is declined in the usual way. To form tens, the above digits are prefixed to the word *dek*: *Dudek* (20), *kvardek* (40), *sesdek* (60), *naudek* (90); and to form the hundreds, thousands, and millions, the same process is adopted: *kvincent* (500), *kvardekmil* (40,000).

The intermediate numbers are placed after the tens, hundreds, thousands, and millions, thus: *dek tri* (13), *kvindek sep* (57), *cent tri* (103), *mil naucent kvin* (1905), *centmil dek* (100,010). Examples:

La knabo vidis dek du aglojn, The boy saw twelve eagles. *Jen estas cent funtoj sterlingaj por vi*, Here is one hundred pounds sterling for you. *Mi havas unu filon kaj ses fratojn*, I have one son and six brothers.

All the above numbers may take the substantival form by adding *o*, when they may further use the final *j* and *n*: *unuo*, a unit; *duo*, a pair; *dekduo*, a dozen; *cento*, a hundred. Examples:

Miloj da homoj, Thousands of men. *Mi aĉetis dekduon da ovoj*, I bought a dozen eggs.

It will be seen that in using this noun form the preposition *da* is employed before the complement. Never say, *Mi havas dudekon pomojn* for " I have a score of

apples." but always adopt one of the two following forms: *Mi havas dudek pomojn*; *mi havas dudekon da pomoj.*

Ordinal Numbers. These are formed by addng *a* to the above cardinal numbers, and the resultant words become adjectives. Of course, if an ordinal number is composed of several words, such as *naudek-kvin* the terminal *a* is only affixed to the last word, but the words are then hyphenated.

Examples: *Li vojaĝis ducent kvindek ses mejlojn*, He travelled two hundred and fifty-six miles. *Li atingis la ducent-kvindek-sesan mejlŝtonon*, He reached the two hundred and fifty-sixth milestone.

This form of numeral is always employed in expressing dates, the time of day, and the numbers of pages. Examples:

La deka domo sur la strato, The tenth house in the street. *Mi alvenos je la kvara horo*, I will arrive at four o'clock. *Li legas la paĝon tricent-kvaran*, He is reading page three hundred and four. *La kvaran de Majo*, (on) the fourth of May.

Note that there is no conjunction in the compounded numerals.

Following the general rule these words may be used adverbially, and so we obtain: *Unue*, firstly; *deke*, tenthly. Examples:

Unue, li parolis pri morto, First of all he spoke about death.

Oke, vi ne devas ŝteli, Eighthly, you must not steal.

The words, once, twice, thrice, etc., are formed by adding the word *foje* (*fojo*, time) to the cardinals. We thus obtain *unufoje* (once), *dufoje* (twice), *trifoje* (thrice), etc. The substantive may also be used to express these terms, but in this event it is generally in the accusative case. Examples:

Tri fojojn mi frapis la pordon, Three times I knocked at the door. *Li kriis du fojojn*, He cried twice.

aer', air
akr, sharp
atend', await, wait, expect
ating', attain, reach
cel', aim, object
col', inch
ĉapitr', chapter
dezir', desire
dolĉ', sweet
dorm', sleep
ekzerc', exercise
elekt', choose
erar', error, mistake
fidel', faithful
fingr', finger
flank', side, flank
flor', flower
forges', forget
freŝ', fresh
fru', early
fut', foot (measure)
glav', sword
grav', important, serious
ĝentil', polite
hel', clear, glaring
hor', hour
intenc', intend
jun', young
juvel', jewel
kaleŝ', carriage
kapabl', capable
kaŝ', hide (v. t.)
kat', cat
lern', learn
lert', skilful
lum', light
lun', moon
pel', drive, chase
pied', foot
tranĉ', cut
trink', drink
tromp', deceive
trotuar', sidewalk
tur', tower
vetur', journey (by vehicle)
viand', meat, flesh
vic', row, rank
vizaĝ', face
vok', call
volum', volume

Exercise VI.

At early morning the air is very fresh. The sword is sharp, and cuts easily. I have two hands and ten fingers. Firstly, I desire to tell the truth, and, secondly, I want to be agreeable. In the field, at the right-hand side, stand two old trees. To-morrow we intend to journey to London in the carriage. A foot has twelve inches. You must not forget to learn Exercise 6. The child sweetly sleeps under the clear light of the moon. He read the tenth volume first. The young soldier is stupid and clumsy. My faithful dog will wait for me, and I shall not forget to give him some meat. They made a great mistake, and hid the beautiful jewel. Your young friends are very capable. My error is not very serious, and I do not wish to deceive you. Thirty-eight and twenty-seven make sixty-five. A week has seven days. The first is Sunday, the fourth Wednesday, and lastly comes Saturday. They will remain at home (adv.) during the day. To-morrow morning (adv.) I will await your arrival at nine o'clock. The skilful and capable boy stands in the first rank. His object was to deceive the king, to drive away the soldiers, and hide himself.

Key to Exercise 4.

Hieraŭ mi estis malsana. Hodiaŭ mi estas sana. La birdo en la kaĝo estas kanario. Li kaptis ĝin hieraŭ. La ĉerizoj estas maturaj, kaj vi povas manĝi ilin. La skatolo enhavas cigaredojn kaj alumetojn. Li abonas la ĵurnalon kaj la gazeton. Kara sinjoro. Tempo flugas, kaj ni devas eliri. Esperanto estas facila. Li havas leteron en la mano, kaj ĵurnalon sub la brako. Ŝi havas blankan ĉevalon kaj belan hundon. Morgaŭ ni iros al la teatro. Ni ridos kaj estos gajaj. Li estas riĉa kaj pagos al vi. La glora heroo alvenos morgaŭ, kaj vi vidos lin. La tablo estas alta kaj ronda. La leono estas danĝera besto. Vi trovos la ganton kaj la bastonon sur la tablo en la ĝardeno. Mi skribis la leteron, kaj li detruis ĝin. La generalo kun la barbo estas dika, kaj la malriĉaj soldatoj estas maldikaj. Ili estas saĝaj, kaj amuzos sin. Mi povas aŭdi la ĉhon. La kuzo estas malagrabla hodiaŭ. La suno estas en la ĉielo. Morgaŭ mi aĉetos la horloĝon, kaj ĝi al mi apartenos. La soldatoj estas honestaj kaj gajaj. La afero estas malfacila. Morgaŭ mi decidos pri gi, kaj vi povas esti certa pri la rezultato.

Key to Exercise 5.

Vi estas prava (or pravaj), kaj mi estas tute malprava. Ni ne devas stari sur la ombro de la reĝo. Vi estos feliĉa, kaj mi devas kore gratuli vin. Li estis tre kolera kaj volis min bati. La knaboj lavis sin en la rivero. Vi devas iri al la maldekstra domo. Kelkaj stratoj en la urbo estas tre malbelaj. Li diris al mi diversajn strangajn detalojn pri la okazo, kaj mi volonte kredis al li. La ovoj estas malbonaj, kaj vi ne devas manĝi ilin. Vivi simple estas vivi feliĉe. Vi povas havi la brunajn kovertojn, la bluaj ne apartenas al mi. En la silentaj kampoj li ofte sidas, kaj rigardas la birdojn sur la arboj, kaj la gloran sunon sur la ĉielo. Senparole, li kolere eliris. Oni ofte vidas strangajn domojn en vilaĝoj. Ili estas ekstreme vanaj, kaj sidas aparte de ni. La hundo bojas laŭte. Ĝi soifas kaj deziras akvon. Kelkaj knaboj volis malfermi la fenestron. La ceteraj ne aprobis la proponon, kaj ne volis resti en la ĉambro. Morgaŭ matene oni povos nin trovi ĉe la hotelo kun la aliaj sinjoroj.

Continued

THE VYNER WINDOW, CHRIST CHURCH CATHEDRAL, OXFORD

STAINED GLASS

How to Design a Coloured Window. Selecting and Cutting the Glass. Arranging the Leads. How Shading is Applied. Firing the Glass. Application of Stain

By E. J. PREST

THE art of working in stained glass, although it has great and noble possibilities, is comparatively simple in its methods. It is essential, however, in order to attain success, that the student should be sufficiently well equipped with a facility in drawing and designing; a knowledge of the harmony of and a natural feeling for colour, and an acquaintance with style in architecture and decoration.

Use of Coloured Glass. It is a popular error to suppose that various coloured pigments are used in the production of a stained glass window, such as a landscape or portrait painter would use in his picture. Colour is obtained only by the careful selection and arrangement of various pieces of coloured glass cut to the necessary simple forms, and placed together in the form of a mosaic.

Thus, a red dress is cut out of a sheet of red glass, the head, hands, and white draperies of a figure out of white glass, the sky probably out of blue glass, a tree out of green glass, and so on. The pieces of glass would then resemble a picture puzzle, each form fitting into the other.

On these pieces of glass the outlines are painted with a specially prepared brown pigment, the only colour used in painting glass—another important principle to remember—and by this means the folds are indicated on the piece of red glass forming the dress, the drawing of the features and limbs upon the white glass, and the leaves of the trees on the green glass. This brown pigment is prepared, as will be more fully explained, so that the process of burning or firing the glass in a kiln fuses the colour into the surface, and the outlines and shading become absolutely imperishable. The pieces of glass are finally joined together with strips of lead, grooved at each side to hold the glass, and soldered at the joints where the leads meet.

This, then, is roughly the process followed in making a stained glass window; and it will be seen that there is ample scope for the exercise of the artist's individuality—first in designing his window; further, in the judicious selection of his coloured glass in which to carry it out; in the painting, and in the final stages of making it up into a wind and weather tight transparency—light-giving and yet rich and subdued in effect.

How to Become a Designer. In order to design and draw satisfactorily for stained glass, careful study should be made of the best existing examples, both ancient and modern. It is better to begin in a simple way, and so gain a knowledge of the possibilities and limitations of the material. The student should become acquainted with the examples at South Kensington Museum, where the gradual evolution from the earliest to the latest periods of mediæval glass may be seen, as well as interesting specimens of modern work, and, above all, the noble and dignified full-size cartoons by Burne-Jones for St. Philip's Church, Birmingham. The work of this artist will stand as the most typical of the best glass of the nineteenth century, and it is for this reason that one of his windows has been selected as an illustration to this course.

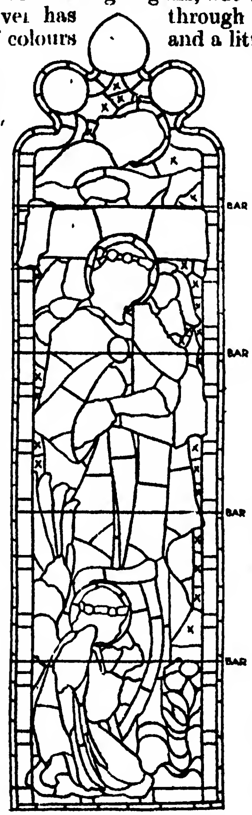
The Coloured Sketch. It is usual at the outset to make a carefully coloured sketch to 1-in. scale, showing the design of the window proposed to be carried out. From this, in turn, the full-size cartoon is drawn in chalk, pencil, or sepia. If the beginner does not feel sufficient confidence to design for himself, he cannot do better than enlarge some of the simple figures drawn for glass by Ford Madox Brown, or, failing that, some of the early German prints of the school of Dürer, such as the "Apocalypse." Fig. 2 is an example of a stained-glass cartoon, drawn to full size in chalk and pencil, of a figure forming part of a window designed to illustrate Music, and carried out by the author, and it is proposed that this drawing should serve as our text in explaining in detail the various stages to be gone through before it is ready for placing in position in the building for which it was designed.

The Cut Lines. Having prepared the full-size cartoon, a piece of tracing cloth or thin glazed calico is laid over it, and on this is traced, with a brush, in ink or black water-colour, the black lines showing the shapes in which the glass is to be cut, and these lines indicate what will hereafter form the leads joining the various pieces of glass together. This tracing is technically known as the "cut line"—namely, the lines showing the cuts [1], and is usually made by an intelligent craftsman, if not by the artist himself, as it is necessary that the forms should be as simple as possible to avoid risk of breakage in the process of cutting. Moreover, it will be seen that many cuts are added to those shown on the original cartoon for the reason that it is impossible to fire in the kiln any piece of glass more than about 10 in. square without serious risk of breakage. These additional cuts are shown in 1 and are omitted in 2. They should be dealt with boldly, and, as far as practicable, at right angles to the outlines forming the drawing. Never shirk the leads; they are of immense value to the effect of the window; moreover, we have no reason to be ashamed of the means of our craftsmanship—we are producing a window in painted and leaded glass, not a picture painted in colour. It is the practice of some to mark on the cut line with an X the plain pieces of background to a subject, as shown in 1. This saves time in laying out the pieces of glass on the cut line hereafter.

Selecting the Coloured Glass. The artist now takes the cut line and cartoon, and, with his original coloured sketch before him, proceeds to the all-important and intensely interesting task of selecting the coloured glass in which his design is to be interpreted. The kind of glass used for this purpose is known as "antique," made in sheets about 2 ft. by 1 ft. 4 in. and varying from $\frac{1}{8}$ in. to $\frac{3}{8}$ in. in thickness, the making of which is the result of much chemical research and subtle handicraft, and is dealt with fully in the article on Glass on page 4930. Let us, however, here emphatically deny the popular fallacy, for which cathedral vergers are chiefly responsible, that the art of making coloured antique glass is lost. Never has there been such an exquisite gamut of colours to select from as we have now, and the indescribable beauty of variation in the best antique glass can only be appreciated when seen in the full-sized sheets as they come from the maker.

In the drawing illustrated the principal figure is in white and gold, with a chaplet of roses around the head; the lining of the cloak is greenish white, and the underdress nearly a pure white. The background consists of varied tones of rich, deep orange and russet. The cherub's wings are crimson, technically known as "ruby," while the chief colour note is confined to the lower kneeling figure playing the harp. Here the wings are in exquisite, varied, rich peacock blue and green, and the drapery a soft purple madder colour. The square blocks in the border are blue and green alternately, and the remaining portions of the window in varying tones of white.

In order to produce harmony of tone and colour in a window, the white glass should have a slight tone of grey-green similar to the colour of a soda-water bottle. The contrast of pure white glass coming sharply against rich colour would be spotty and suggestive of holes in the window, which is emphasised again by the solid black outlines formed by the leads.



1. THE CUT LINE
X. Plain background

Cutting. The various sheets of glass having been carefully selected, the next step is to get it cut to the shapes shown by the cut line. This operation is a purely mechanical one, but requires a considerable amount of practice and skill. Now, if this diagram of the cut line be carefully examined it will be seen that none of the shapes present any great difficulty in cutting. Care should be taken to avoid forms like those shown in 5, for they would certainly break where the dotted lines occur.

Cutting may be done in either of the two following ways. The shapes are cut out of stout cartridge or brown paper; these are laid upon the glass, and the diamond [8A] drawn around them, making a clean cut on its way. The edges of the glass are then easily broken away with the fingers, or, if small, with pliers.

The second method is the one now generally adopted, and for this is used the steel cutting-wheel [8B], which can be bought for a few pence, and is quite as good if not better than the expensive diamond for cutting glass to any shape desired. The sheet of glass is laid upon the cut line, and the black line which shows through is carefully followed, freehand, with the wheel. This is a simple process with white or light-coloured glass, but where the colour is too dark to be seen through the glass should be breathed upon, and a little fine whiting dusted upon it from a pounce bag, which is a small piece of muslin or linen containing dry whiting tightly tied up. The glass is then placed beneath the drawing, and the line traced over with a finely-pointed stick, or the edge of a blunt knife, when the shape will be found marked on the glass, and can be easily cut.

Don't waste glass unnecessarily in the cutting process. Antique glass is expensive; therefore, place your pattern carefully on the sheet of glass with this object in view, keeping any pieces over 2 in. or 3 in. square in small wooden boxes, one for each colour if possible.

Painting Colour on the Glass. The glass, being all cut to shape, is now laid out in its proper place on the cut line and every piece well cleaned to remove greasiness. The next operation is to trace with a fine, long-haired brush called a *tracer* [8A] the outlines of the drawing upon the glass using the brown tracing pigment already referred to. This pigment is in the form of brown powder, and consists of iron oxide and manganese ground up with powdered flint glass or other silicate, which, by the action of the fire when in the kiln becomes fused into the surface of the glass and forms really a part of it, whence the indelibility and lasting qualities of stained glass.

Glass-painting colour, as well as suitable brushes for tracing, stippling, and other methods of painting to be explained, may be obtained from the artists' colourman.

To prepare the colour, get a slab of thick glass,—ground plate is the best—and a muller. Take a little of the powder tracing colour and with clean water grind it to a smooth paste, then, with the addition of a few drops of ordinary gum, or a little sugar ground well up with the muller into the colour in order to make it flow freely, it is ready for use. A *palette knife* is necessary to keep the colour well mixed together during use, and in the centre of the palette or slab for

convenience in working. A *wooden rest* [4] should be used to raise the hand above the glass, which gives greater freedom and prevents the glass from becoming greasy from contact with the skin.

The Tracing Process. The student should begin by learning to use his tracer freely in strokes such as are shown in 6A, and then go on to simple forms such as 6B, aiming to get his lines clean and true, as far as possible with one stroke of the brush. This will entail considerable practice, but a good beginning is everything, and in course of time he will be able to undertake the outlining on glass of such a cartoon as we have illustrated. To do this, the cartoon should be laid upon the bench, and each piece of glass taken separately, one at a time, laid in its proper position over the drawing, and the outlines, which will show through, carefully reproduced on the glass. Many artists fire in these outlines before proceeding to the shading in colour on the glass, and the beginner may do so, but as he gets more experienced he will find this unnecessary, and will get better effects by sometimes losing these hard outlines in the subsequent shading, especially in very delicate work, but in this case he should use gum in his colour and not sugar.

The tracing process having been completed, the cut line is placed face upwards upon a bench and over it is placed a sheet of very thick *sheet* or ordinary *plate* glass, which is called the *easel glass*. On this all the various pieces of glass are laid out in their proper places as shown by the outline underneath; this is like the putting together of the map or picture puzzle. Some good beeswax is then dissolved together with a little resin in a small saucepan, and dropped while hot and melted with a small strip of glass in between the pieces of glass at the points where they meet each other. By this means the whole subject in stained glass becomes fixed to the easel glass, and it can now be safely held up to the light, and the first view obtained of the colour effect and tracing lines as a whole. It may be found necessary at this stage to make some alterations, especially in the first essay. Colours may not go well together, others be too light or too dark, and it is only by long experience and a natural gift and feeling for colour that quite satisfactory results will be obtained.

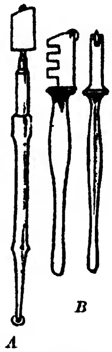
2. PORTION OF MEMORIAL WINDOW
(Chapel Royal, Savoy)

Shading. This plate glass with the pieces of glass composing the subject *waxed* or *stuck up* upon it is now placed on a specially constructed easel used by glass-painters in front of a window with a good light for the *shading* process. The usual and most successful method is to wash in the main shadows in water colour with a large soft camel-hair brush [8B], using, of course, the specially prepared shading colour for this purpose. The edges of the shadows should be softened off, and not too much gum used in the colour. When this has been done all over the window, and is quite dry, a *matt* or scum of full colour should be laid evenly and quickly over the whole with a larger flat camel-hair brush [8C], and while still wet softened and made even with a badger-hair softener [8D], and then stippled or dabbed all over with a *stippler* [8E] a brush specially made for this purpose. This is a process requiring great facility and rapidity of handling, as it must all be done before the colour dries, and should be practised upon some plain pieces of glass first. By this means a granulated and transparent effect is produced, and if carefully done, the outlines, being traced in gum colour, will not be disturbed; the shadows also, being in softer colour will work up into the matt and add to its strength.

This matt of colour, when dry, represents the whole of the window in shadow, and the process of modelling or shading is just the opposite to what the student has been in the habit of doing in making drawings in chalk at an art school—the lights are taken out of the shadows instead of the shadows being added to the lights; in other words, we have to work from dark to light instead of from light to dark.

Taking out the Lights. First of all the broad high lights are taken out by removing the colour boldly and sharply with a soft-pointed stick or broad-pointed quill pen, and afterwards the matt is gradually brushed away with the short hog-hair brushes called *scrubs* [8F], copying from the full-size cartoon and getting the careful shading and modelling of the various parts of the subject shown thereon. This part of the work requires

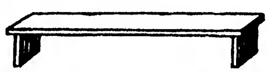
the greatest care and artistic feeling, but it is impossible to explain the process further in an article of this nature. Success will only come by long practice, or by watching an experienced glass-painter at work. Care should be taken to work with a view to the ultimate position and distance of the window when fixed; if close to the eye, it should be more delicate in finish, and if for a high clerestory window, broad and telling in effect, but in any case care should be taken to prevent the shadows from being dense and opaque. If they are found too heavy after the painting is completed they may be reduced and lightened by using a very fine needle point in the manner of an etching, but this requires judgment and delicacy of handling.



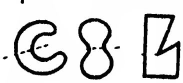
3. DIAMOND CUTTERS
a. Glazier's diamond *b* Steel-cutting wheel (side and front views)

Firing. After the painting is finished the easel glass is taken down and again laid flat upon the bench, when a few sharp taps upon the edges of the glass with the handle of the palette knife will loosen the pieces and they may be easily removed, care being taken to remove or chip off all the loose pieces of wax at the edges The pieces should then be carefully laid in shallow wooden trays for removal to the kiln.

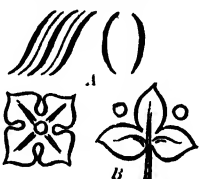
The most convenient form of kiln now in use is known as the *closed gas kiln* [9]. The glass is placed on shallow iron plates, which are covered with a bed of powdered whiting or plaster of Paris, and subjected to a gradually increasing and intense heat, which fuses the colour into the surface of the glass until it becomes incorporated with it, and is absolutely permanent. The actual amount of firing necessary can only be found out by long experience, and it is the practice of most craftsmen who are keen on the success and permanence of their work to watch the firing themselves. The first firing especially should be very thorough, and not too quickly done; the pigment fuses and unites better with a slow and gradual heat than with a fierce and rapid one. It is best to place all the pieces of white glass and the harder colours, such as ruby, together, as these stand a harder fire, while the soft glasses, such as blues and greens, fuse at a slightly lower temperature.



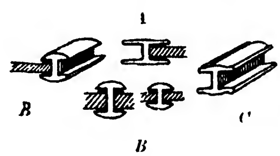
4 HAND REST FOR USE WHEN TRACING OUTLINES



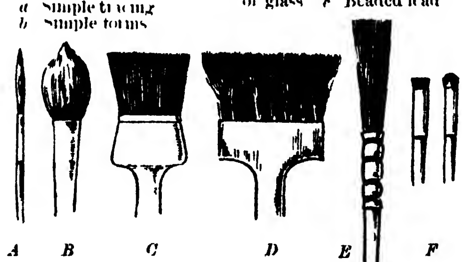
5. SHAPES TO BE AVOIDED IN CUTTING GLASS



6 ELEMENTARY TRACING
a Simple tracing
b Simple forms



7 SECTIONS OF LEADS
a Flat outside lead *b* Ordinary lead as used for varying thicknesses of glass *c* Beaded lead



8. BRUSHES USED IN PAINTING GLASS
a Tracer *b* Camel-hair for washing in shadows *c*. Flat for laying matt all over glass *d*. Badger for softening matt *e*. Stippler for giving granulated effect *f*. Hog-hair scrubs for taking out lights

When the glass has become quite cool in the annealing chamber of the kiln, which usually does not take place until the day after it has been fired, it is taken out and again stuck up with wax, as before, on the easel glass. The painter will probably be disappointed with the result at first; he will find that the shadows have fired away, and the whole subject looks thin and weak. It is better so than that the first painting should have been too heavy and the shadows coarse and opaque.

The Second Painting. The *second* painting is now done, but in a more general way than the first, greater attention being paid to breadth of effect than to detail; in fact, the whole thing needs pulling together A second stipple, or in some cases a matt only, is covered over the parts that need strengthening, and instead of using the scrub, a better and softer effect is obtained by rubbing the colour lightly with the finger. Some artists finish the work with oil medium to obtain softness, but at the risk of losing transparency, which is of the utmost importance in stained glass, and should be borne in mind as an important principle from first to last.

At this stage, the diaper patterns, which give such a rich effect to draperies, should be traced in outline in a delicate and artistic manner, and special attention should be given to the finished painting of the heads and flesh portions of the subject.

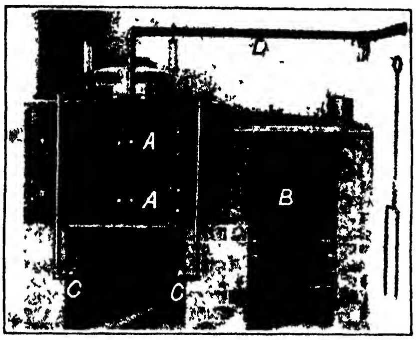
The glass is now fired as before, for the second time, but not quite so heavily, and, provided the second painting has been successful, the only thing remaining is to apply the silver stain which gives such exquisite yellow and golden effects in stained glass

The Value of Silver Staining. Staining is applied to the back of the glass, and is most useful for armour, yellow flowers, diaper patterns on draperies, golden hair (when not overdone), and on a sensitive blue glass for producing green foliage This stain is made in the following way. Into a wide-mouth bottle put two ounces of nitric acid, and three ounces of boiling water; then put into it one ounce of pure silver, and stand the bottle up to its neck in boiling water. The silver will then dissolve, and take the form of a nitrate. This must be plunged into boiling water and precipitated by the addition of common salt; the precipitate is

again washed several times in hot water, collected on a piece of absorbent paper, and thoroughly dried. One part of the dry precipitate is then mixed with two parts of yellow lake, and thoroughly well ground with a muller on a slab of glass, mixed with either water or turpentine, the former for preference. This is now in the form of an opaque yellow mixture, which is applied with a soft brush to the back of the glass where required, and the glass is afterwards fired for a third time, but at a much less degree of heat than was necessary for the colour.

When cool, and held up to the light, it will be found that the yellow has become beautifully transparent, and is a perfectly permanent stain. It is well to test small pieces of glass with stain in the kiln before applying it to an important piece of work, as some kinds of glass are much more sensitive than others to the action of the heat in staining.

Glazing. One other operation remains for the glass to undergo, but it is purely a mechanical one—that is, the *glazing*, or joining the pieces of glass together with the grooved leads, illustrated in 7. The cut line is pinned down, face upwards, upon a bench, and the pieces of finished glass laid out on it in their proper places. A broad wooden *straightedge* is nailed down along the side, leaving space beyond the edge of the cut line for the wide and flat outside lead, which fits into the *rebate* or *groove* of the window. Another straightedge or lath is nailed at right angles to this, along the bottom of the cut line, and working from the corner thus formed, each piece of glass has the pliable grooved lead bent around it and is fitted into its place. Each of these pieces is temporarily held in position by nails until the next is fitted, and so on until the whole is framed together in lead. The joints where the leads meet are then soldered with a specially constructed gas soldering iron. When this is finished on the one side, the window is carefully turned over on the bench and the joints at the back are soldered in the same way.



9. GAS KILN FOR FIRING GLASS
a. Chambers in which glass is fired *b*. Annealing chamber in which glass is cooled *c*. Gas burners *d*. Gas supply pipe
(Payne & Co., Kilburn)

The window can now be held for final inspection, and it will be seen at once what great value is given by the black outlines formed by the leads.

A word of caution is necessary in handling a panel of stained glass: it should always be carried and lifted edgewise, and not flat.

Cementing. In order to make the window weather-tight and rigid, a stiff cement, made of whiting, plaster of Paris, a little red lead, boiled oil and turps, with lampblack to colour it, should be well brushed in under the leads with a stiff brush, afterwards cleaning away the cement remaining on the surface with clean plaster or sawdust and another stiff brush, like a domestic scrubbing brush. The edges of the leads are then picked around clean with a pointed stick. The window should stand for a few days to allow this cement to harden, after which it will be ready for fixing.

Where to Study. This is briefly the story of the making of a stained-glass window; but there are many technicalities and methods other than those explained, which are learnt by experience, and can scarcely come within the range of a short article. Several of the County Council Schools of Art are now making the teaching of stained glasswork a special feature, and the student is recommended for further information to get Mr. C. W. Whall's book on "Stained Glass Work," which is lucid, technical, and the work of an enthusiast, and for full information as to the history and evolution of the art, Mr. Lewis F. Day's book on "Windows."

Much can be learnt from the careful study of good work, both old and new, when one is able to separate the wheat from the chaff as regards the latter; the frontispiece to this part is an excellent example of the art, both for its simplicity and dignity of arrangement and beauty of colour.

It serves admirably to illustrate the general principles laid down in this article; the simple cutting forms should be especially noted, and the manner in which the leads are boldly carried across the drapery where required. The figures in pearly white, enriched with delicately traced and stained diapers are in bold relief against the full rich blue of the screen background; full colour is judiciously used, yet the whole effect of the window is light-giving and brilliant. The small subjects below are masterly in their simplicity of design and arrangement. Stain is sparingly used, and may be noted in parts of the hair, the crown of David, the diapers on the robes, and in touches on the blue background to the figures. The bands of lettering are picked out of a deep matt of colour. The nimbuses surrounding the heads of the principal figures are in brilliant "gold pink" glass, left unpainted, the exquisite variation in colour being produced by the glass-maker.

Other windows, by Burne-Jones, that will repay study are those in St. Philip's Church, Birmingham, and Holy Trinity Church, Sloane Street, London. There is little old work to be found in London, and most of it is late in character—namely, the east window in St. Margaret's Church, Westminster, and some windows in the gallery of St. George's Church, Hanover Square.

The city of York is a veritable treasure store of old stained glass, and much fine work exists at Malvern, Tewkesbury, and Fairford.

GLASS *concluded; followed by* POTTERY

Continued from page 4843

QUEEN ANNE

War of the Spanish Succession. The Taking of Gibraltar. The Career of the Duke of Marlborough. Union of England and Scotland

By JUSTIN McCARTHY

ANNE was born at St. James's Palace on February 6th, 1665. When James became a Catholic his daughters, whose mother had lately died, were brought up as members of the Church of England. Anne's religious opinions never underwent any change. When in her twentieth year she was married to Prince George, brother of the King of Denmark, who was an idle, good-natured, and utterly unintelligent person.

The Succession. When the great political crisis occurred Anne and her husband abandoned the cause of King James, and in 1689 the Crown of England was settled on her as successor to William III. The question of succession was one of great difficulty. As the Commonwealth system had been entirely overthrown it was necessary still to maintain the conditions of hereditary rule, while it was desirable also to shut out the Stuart claimant, the Prince of Wales, from all chance of governing the State.

Anne's succession to the Crown was a matter of compromise, and the question of a successor to her had to be a matter of compromise also, for Anne's many children nearly all died at birth, or during infancy. It was at last determined that her successor should be George, son of the Elector of Hanover and Sophia his wife. The Electress of Hanover was, by her mother's side, the grand-daughter of James I., but she belonged to a German family which was not likely to have any sympathy with the Stuart cause. Thus, by the Act of Settlement of March 12th, 1701, the way was secured for the Hanoverian dynasty in England.

This was before Anne came to the throne, but only a year had passed when, on the death of William III., Anne, the last of the Stuart dynasty, became Queen of England. She took little interest in politics, was easy-going, and, like other Stuart sovereigns, loved to be under the guidance of some favourite. One of her earliest favourites was her Lady of the Bedchamber, Sarah Jennings, wife of Lord Churchill, afterwards Duke of Marlborough, who soon obtained a complete control over the Queen, which she exercised in favour of her husband.

The Duke of Marlborough. Marlborough must, under any conditions, have made a great name in history, and the time was well suited to create a stage for his brilliant qualities. He had many defects of character: he was selfish, ambitious, unscrupulous; but he had also, apart from his genius, qualities which won him admiration and affection. He had a handsome presence, and manners both winning and stately. His chief aim had always been to advance his own prospects. He stood by James II. as long as it seemed to be for his own interest, but as soon as he saw that the King's cause was hopeless he deserted to William of Orange. The Duchess Sarah is conspicuous in history because of her influence over Anne, and their correspondence is an historical document. "If ever you should forsake me," the Queen wrote on one occasion, "I should have nothing more to do with the world; for where is a crown when the support of it is gone." However, when the separation took place Anne found a new favourite in Abigail Hill. Under her influence a Tory Ministry was formed, St. John and her cousin Robert Harley being at the head of the Government.

The words "Whig" and "Tory" had not the same meaning then as in more modern times. The Tories in Queen Anne's day were generally in favour of Divine right and the Stuart dynasty, while the Whigs believed in hereditary succession on the principles of the Act of Settlement. The Tory leaders when Anne succeeded were Robert Harley and Henry St. John. Harley was a man of great capacity, while St. John was a man of genius. So far as Anne had any political creed she was opposed to that principle of constitutional liberty which had secured her own succession.

Defoe and the State Church. There were many religious troubles at the time besides the struggle between Catholics and Protestants. The Dissenters were increasing, and the members of the Established Church endeavoured to suppress the right of private judgment, and to shut out from office all those who deviated from the doctrine or practice of the State Church. But the Dissenters were becoming more powerful, both in England and Scotland, and were setting themselves vigorously against the rigid rules of the Church of England. The sympathies of the Queen were believed to be with those who maintained the supremacy of the State Church over all forms of Dissent. During this crisis appeared Daniel Defoe's famous pamphlet. Defoe was the son of a London butcher, and was educated at a Dissenting school. He took part in Monmouth's rebellion, but was fortunate enough to escape. He afterwards served in King William's army, and travelled in France and Spain. He wrote several successful pamphlets, and, being a staunch supporter of the cause of the Dissenters, he published in 1702 his famous pamphlet, "The Shortest Way with the Dissenters"—a forcible satire which was taken by most of the public to be the sincere declaration of the policy of a rabid Churchman.

When the satire was generally recognised as such, the High Church party brought the pamphlet before the notice of the House, and

Defoe was sent to prison, where he published the "Review," the predecessor of the more famous "Spectator." Among those who had the courage to plead his cause was William Penn, the Quaker who founded the State of Pennsylvania in America, called after his father, Admiral Penn. William Penn was sent down from Christchurch, Oxford, when he became a Quaker, and had been imprisoned for his religious opinions. He was naturally in sympathy with Defoe, and exerted himself to obtain his release. Defoe was released in 1704 by the influence of Harley, who hoped to win him to the Tory side. He was again imprisoned in 1711, and again released by the exertions of Harley. His most famous work, "Robinson Crusoe," did not appear in the reign of Queen Anne.

A Time of War. Anne was naturally of a peaceful disposition, but it was her fate to reign at a time that will ever be remembered for its wars. Europe was then in a most disturbed condition. The great ambition of the King of France was to make France the mistress of the Continent, and to this end he desired to take from Spain all that was left of her power, and to prevent the States of the Netherlands from rising into real influence. Louis XIV. well knew that he would have to count on the opposition of England. The two States had long been enemies, and the policy of Louis made that enmity stronger. Germany was still in a very unorganised condition; Austria was the greatest German State and, though the Emperor was still elected to the throne like the Princes of Saxony, Bavaria and others, the Emperor was as sure of election when his predecessor died as if the principle of hereditary succession had been acknowledged in Austria. The Electorate of Brandenburg soon after this became the great Kingdom of Prussia. England and Holland joined in an alliance to prevent Louis XIV. from adding Spain to his dominions. Some of the German States joined England and Holland, and some took the side of France. The Methuen Treaty with Portugal was concluded in 1703 by Paul Methuen, the English Ambassador at Lisbon. It gave an advantage to the wines of Portugal over that of France, and helped to secure the alliance of Portugal.

War of the Spanish Succession. France had few allies of importance when the war broke out. The Duke of Vendome and the Duke of Berwick were among the great soldiers who led the armies of France. England was much embarrassed at this time by the discontent in Scotland caused by the opposition of the Scottish Parliament to the Union scheme, and France was much troubled by the rebellion in the Cévennes Mountains caused by the intolerant policy of Louis XIV. A rising took place there immediately after war had been proclaimed. The Dutch allies of England put their forces under the command of Marlborough, who in this war proved himself one of the greatest commanders of all time. Prince Eugene was his most distinguished comrade, and helped him in some of his greatest battles. Marlborough determined to drive the French into a pitched battle, and thus to gain a decisive victory.

Great Battles. While the French were still uncertain of his plans, he suddenly crossed the Neckar, pushed through Germany towards the Danube, which he crossed, and made his way to Bavaria, where he joined his forces with those led by Prince Eugene. There he encountered the French and Bavarian Army, under Marshal Tallard, of 60,000 men, the English Army numbering 40,000. On the morning of August 13th, 1704, was fought the famous Battle of Blenheim, where Marlborough won a complete victory. The loss on the French side was enormous, and Tallard was taken prisoner.

At the beginning of the Spanish War Lord Ormond had been sent to Spain with Sir George Rooke to assist Spain against France. In 1704 another expedition went out under Rooke, who captured Gibraltar for the English, to whom it has ever since belonged.

In 1705 Charles Mordaunt, Earl of Peterborough, one of the most brilliant figures of that time, who had begun his career as a naval officer but soon entered the Army, captured Barcelona, and established the authority of Charles II. of Spain in Catalonia and Valencia. After his great success he quarrelled with the Archduke Charles, and left Spain rather than submit to the command being divided between himself and Galway. In 1707 he returned to Spain as a volunteer, but was recalled by Sunderland, who was a friend of Galway. In 1706 Marlborough won the battle of Ramillies, in Flanders, where he encountered the French Army under Marshal Villeroi. The Allies thus gained the whole of the Netherlands, and Marlborough then wanted to besiege Mons, but the delay of the Dutch in forwarding supplies prevented this. In Italy Prince Eugene's brilliant relief of the Siege of Turin compelled Italy to join the Grand Alliance. Louis XIV. unsuccessfully tried to make peace, and the war continued. The following year was less successful for Marlborough. In 1708 Vendome captured Ghent and Bruges, and besieged Oudenarde. Marlborough won the battle of Oudenarde in July, and, being soon after joined by Prince Eugene, took Lille and recaptured Ghent and Bruges. Berwick had in the meantime reinforced the French. On September 11th, 1709, Marlborough and Eugene encountered Villars at the Battle of Malplaquet, which was almost as disastrous for the Allies, who won, as for the French, who lost: and the following year saw Marlborough's last campaign.

Politics at Home. We must now return to the events which occurred in England while the war of the Spanish Succession was going on. In November of 1703 a great storm broke out over a large part of Europe. The Navy suffered much from the fury of the tempest, and whole fleets of merchant vessels were torn from their anchorage and cast ashore. The Eddystone Lighthouse of that time was utterly destroyed, and with it perished all those within. Many important political events were occurring at this time in England. There was a growing struggle between the House of Lords and the

House of Commons, which foreshadowed many a later dispute as to the relative power of the hereditary and the representative system. The Union between England and Scotland was finally established in 1706. William III. had declared himself strongly in favour of it not long before his death, but many difficulties had intervened.

The trading and commercial rivalries between the two countries had caused much trouble, and the strong attachment among some of the Scotch to the Stuart cause made many Englishmen dread a Jacobite rising in the north of the country. When Anne succeeded she had been advised by her Ministers to appoint a Commission to treat with Commissioners from Scotland on the subject. The successful accomplishment of the Union was due chiefly to Lord Somers.

The Union of England and Scotland. The Scotch proposal that the Union should be federal was not accepted, and after much discussion the twenty five Articles of Union were drawn up. The more important among them provided that on May 1st, 1707, England and Scotland should be united in one Kingdom; that the succession to the crown should be the same in both countries, and that the United Kingdom should be represented by one Parliament. It was further provided that there should be complete free trade between the people of the "Island of Great Britain"; that weights and measures, laws of trade and customs should be the same in both countries. In all other laws the Scotch insisted on retaining their own systems and the independence of their own Church. The Act was passed, and on March 7th, 1707, the Queen gave her Royal assent to the union of the two countries. The first Parliament of Great Britain met on October 23rd, 1707.

Harley had been appointed Secretary of State in 1706, and St. John, Secretary for War, and they, as heads of the Tory Government, began to fear that Marlborough's incessant and brilliant victories would make him too popular, and, consequently, too powerful in England. They wished to prove the possibility of winning victories without his aid, and, on the suggestion of St. John, resolved to send an expedition against the French in Quebec, and thus distract the attention of Louis XIV. by an attack on a distant part of his dominions. The attempt proved an utter failure.

The End of the War. The Government now began negotiations for peace with Louis. Marlborough was urgent to continue the war, and Prince Eugene came to England to try to persuade the Government to sanction his views. He was unsuccessful, and Marlborough was dismissed and Ormond appointed in his place. But he had none of Marlborough's genius, and the Alliance and the War of the Spanish Succession both came to an end. The Conference was opened at Utrecht on January 29th, 1712, and on April 11th, 1713, the Peace of Utrecht was signed, one of the most important conditions being that which placed the grandson of Louis XIV. on the Spanish throne, with the title of Philip V. Louis was, however, compelled to promise that he and his successor would give no support to the House of Stuart; that Prince James Edward should leave France; and that the Protestant succession through the House of Hanover should be acknowledged by France. A permanent severance of the crowns of France and Spain was also promised; the Hudson's Bay Territories were ceded to England; the Spanish Netherlands were given to the Dutch, and Lille given back to France. By the "Assiento," the grant of slave trade was taken from France and given to England. Queen Anne endeavoured to secure protection for the Catalans, but with little success. The War of the Spanish Succession had caused the sacrifice of many gallant lives, had caused also enormous financial loss to the people of England and the struggle had promised no satisfactory result to this country.

Anne's husband had died in 1708, and the Queen, who was much attached to him, refused to marry again, though there was no direct heir to the throne. In 1709 the famous Dr. Sacheverell preached his two sermons, attacking the Whig Ministry, and Godolphin in particular, whom he called "Volpone." The Government unwisely impeached him, and he was tried in Westminster Hall, and found, in the first instance, to be guilty; but the failure of a subsequent motion was considered equivalent to an acquittal, with the immediate result that he became a popular hero. He was afterwards given a living in Shropshire. Sunderland and Godolphin were dismissed, and a Tory Government came in under Harley.

The Fall of Marlborough. The fall of Marlborough—the most important event of the last years of Anne's reign—was brought about by Harley and St. John when the duke returned to England in 1710. He was accused of having received £63,000 on the contracts for supplying the Army with food and £177,000 on the subsidies for foreign troops. Marlborough defended himself in an eloquent and moving speech; but his enemies triumphed, and he was deprived of all his offices on the last day of the year. On the death of Godolphin, Marlborough went abroad.

St. John was, in 1712, created Viscount Bolingbroke. His intrigues against his rival and colleague, Harley, were successful, and on July 2nd, 1704, Harley was dismissed from office. Bolingbroke had not long gained the undivided power he craved when the Queen died. He hesitated whether he should support the Stuart or the Hanoverian cause; but the Whig dukes seized their opportunity, came into office, and proclaimed George the Elector King.

The reign of Queen Anne, which came to an end on August 1st, 1714, was the age of Jonathan Swift, of Addison and Steele, of the "Spectator" and the "Tatler," of Alexander Pope, and of many other men whose names give a distinctive character to their era.

Continued

THE BREEDS OF POULTRY

A Brief Guide to the Points of Form, Plumage, and Colour of all the Pure Breeds of Poultry

continued from page 4859

By Professor JAMES LONG

FROM time to time standards of excellence have been published describing in minute detail the points of the birds of both sexes of all the pure breeds of poultry. But it has happened that authors differ, and that fashions change. We have therefore, while disclaiming any standard description, arranged in sufficient detail for the purposes of the poultry-keeper the principal points of all the important varieties of poultry known in this country. The reader will find that each description will prove a useful guide, whether he desire to verify the name of a breed or to ascertain whether one or more specimens are eligible for the purposes of exhibition.

The Breeds of Poultry

Dorking	Table fowls. Sitters.
Modern game, Old English game, Indian game, Malay, Aseel	Game varieties. Sitters.
Brahma, Cochin, Langshan	Asiatic varieties. Sitters.
Plymouth Rock, Wyandotte	American varieties. Sitters.
Orpington	English utility. Sitters.
Spanish, Minorca, Andalusian, Ancona, Leghorn	Mediterranean laying breeds. Non-sitters.
Hamburgh, Redcap	English laying breeds. Non-sitters.
Houdan, Crève, Flèche, Faverolle, Bresse	French varieties. Table and layers.
Campine	Belgian variety. Layers.
Scotch grey, Dumpies	Scotch varieties. Utility.
Polish, Sultan, Silky, Frizzle, Bantams (various)	Fancy varieties.

Dorkings. Comb, single or rose, except in silver-greys (these single); erect in the cock, falling over in the hen. Face and ears, red. Wattles, red and pendent. Beak, dark horn coloured in the dark, lighter in the silvers and cuckoos, and white in the white variety. Head, large and broad. Eye, red or yellow. Body, massive and square, with deep, broad breast, and straight keel. Back, medium in length, broad and straight. Wings, large, and closely carried. Neck, well furnished, medium in length. Tail, large and abundantly furnished with broad sickles and coverts. Legs and feet, white, and free from feathers; five toes. Carriage, bold and brisk, yet massive and grand.

Plumage. DARK or COLOURED. Cock: Saddle and hackle, white or light straw-coloured, sometimes striped with black; shoulders to match; outside webs of flight feathers, white; breast, thighs, and under parts, glossy black; wing-bar, green-black. Hen: Hackle, white, striped with black; breast, dull salmon-red, the feathers tipped with black or dark grey; body, a greyish brown, every feather being laced with black, and provided with a white shaft. There is, however, no arbitrary standard of colour in the Coloured Dorking. [See 3, page 4661.]

SILVER-GREY. Cock: Hackle, back, saddle, shoulder, and outside webs of secondary flight feathers, silvery white; remainder of the plumage, brilliant black. Hen: Hackle, pure silver striped with black; breast, salmon-red, gradually becoming dull reddish grey as it approaches the legs; remainder of plumage pure grey, sprinkled or delicately traced throughout with dark grey. [See 7, page 4855.]

WHITES. Snow-white throughout.

CUCKOOS. Cocks: Bluish grey ground, every feather marked or uniformly barred with a much darker tint of blue-grey.

Game. Head, long, narrow, snaky. Comb, single, usually removed with ears and wattles—this is termed *dubbing*. Beak, curved, strong, horn colour in black-reds, dark horn in brown-reds, or nearly black; yellow in piles, horn in silver, and dark horn in golden duckwings. Eye, keen, red in all except the brown-reds, in which it is black. Neck, long. Body, short, wedge shape. Breast, wide, tapering to the tail. Back, flat. Wings, hard, strong, short. Butts and shoulders, prominent. Tail, fine, the feathers curved, narrow, close, whipped, and carried back. Legs and feet, very long, round, straight, and muscular, willow in the black-reds and the duckwings, black in the brown-reds, and yellow in the piles. Carriage, vigorous, alert, bold, and upstanding, showing great length of legs and great height to the head.

Plumage. Generally crisp, short, and hard.

BLACK-BREASTED REDS. Cock: Hackles and wing-bow, orange; saddle, crimson; outer edge of secondary flights—namely, the exposed webs—bay. Remainder of plumage, metallic green-black. Hen: Hackle, gold, striped black. Breast, salmon, merging into the ashy tint of the thighs; remaining feathering, brown or partridge colour, delicately pencilled throughout, inner tail feathers being black.

BROWN-BREASTED REDS. Cock: Hackle, lemon striped with black. Back, saddle, and wing-bow, lemon. Shoulders, metallic black at the points, lemon behind. Breast, black, each feather edged or laced with lemon. Remainder of plumage, black. Hen: Hackle, lemon, the lower portion striped with black. Breast to match the cock. Remainder of plumage, olive, or green-black.

PILES. Cock: Hackle and saddle, orange; back, wing-bows, and top of saddle, maroon. Exposed webs of flight feathers, chestnut. Remainder of plumage, white. Hen: Hackle, white and gold. Breast, salmon. Remainder of plumage white.

SILVER DUCKWINGS. Cock. Hackle, back, saddle, and wing-bows, silvery white. Bars of wing, metallic blue. Remainder of exposed plumage, rich metallic black. Hen: Hackle, silver-striped black. Breast, pale salmon. Thighs, ash colour. Remainder of plumage, light grey, delicately pencilled. Tail, black, outside feathers excepted.

GOLDEN DUCKWINGS. Cock: Hackle, light cream. Back, saddle, and wing-bows, light orange. Outside web of flight feathers, white. Remainder of plumage, metallic black. Hen: Hackle, silver, streaked with black. Breast, salmon. Thighs, ash colour. Remainder of plumage, delicately pencilled steel-grey. Tail, black, outside feathers excepted.

Among other less known varieties are the red and the silver wheaten, the birchen, the tasselled, the duns, the blacks, and the brassy-winged game.

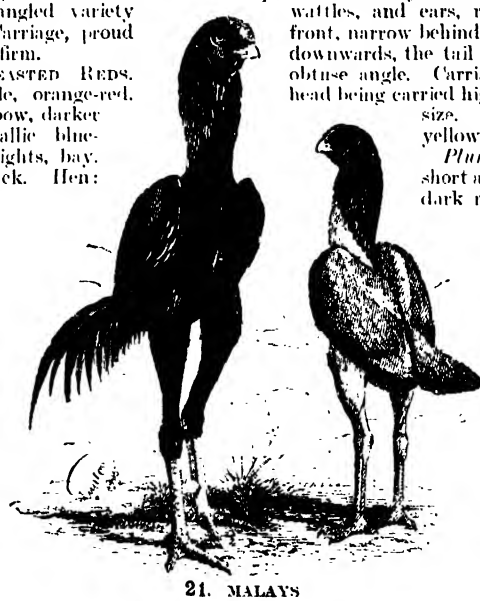
20. LACED-FEATHERED INDIAN GAME HEN

Old English Game. Cock: Head, of medium length and breadth. Comb, single, rather small [**33**]. Eye, red: exceptions, in brown-reds, blacks, and brassy-winged, red or dark; in spangles, red or daw. Face, ears, and wattles, red. Beak, strong, matching the legs; exceptions, in brown-reds, dark horn; in whites, yellow; in blacks and brassy-winged darker horn. Body, broad in front, flat on the top, straight breast, tapering from breast to tail. Wings, longer than in other game fowls. Tail, long, full, flowing, with abundant broad sickles, and hangers. Legs and feet, of medium length, set on short, strong thighs, and of any clear colour peculiar to game; exceptions, dark in brown-reds, willow or white in piles: white, willow, blue, or olive in silver duckwings; white or willow in white game; in the spangled variety they may be mottled. Carriage, proud and courageous, the body firm.

Plumage. BLACK-BREASTED REDS. Cock: Hackle and saddle, orange-red. Back, shoulder and wing-bow, darker red. Bar of wing, metallic blue-black, exposed web of flights, bay. Remainder of plumage, black. Hen: Hackle, golden striped black. Breast, salmon. Body and wings, partridge-brown. Tail, black, shaded with the same brown colour.

BROWN-REDS. Cock: Hackle and saddle, orange-red, striped with black. Shoulders and back, red. Breast, brown, black shading. Wing, black or dark brown. Tail, black. Hen: Hackle, black, striped gold. Tail, black. Rest of body, black, or dark brown mottled.

PILES. Cock: Hackle and saddle, orange or bright chestnut red. Shoulders and back, darker red. Bar of wing, white. Exposed web of flights, bay. Breast, belly, and tail, white. Hen: Hackle, bright chestnut. Breast, darker chestnut. Thighs, lighter chestnut. Remainder of plumage, white.



21. MALAYS

WHITE AND BLACK. Pure white and metallic black throughout. Brassy-winged game, resembling black, but marked with bright orange on shoulders.

SILVER DUCKWINGS. Cock: Hackle, shoulders, saddle, back, and wing-bow, clear, silvery white. Bar of wing, blue-black. Breast, thighs, and tail, black. Exposed web of flight feathers, white. Hen: Hackle, silver white with black stripes. Breast, fawn. Tail, grey black. Back and wings, dark grey.

Indian Game. Cock: Head, broad, lengthy, heavy over the eyes. Comb, pea. Face, wattles, and ears, red. Eye, varying with the plumage, light yellow to red. Beak, varying from yellow to horn. Body, broad-breasted, narrow behind. Shoulders, prominent, deep, thick. Wings, short and closely carried. Tail, close, of moderate length, metallic black. Legs and feet, orange or yellow, thick, powerful, medium in length. Carriage, bold, erect. Back, sloping towards tail which droops. [See **5**, page 4662.]

Plumage. Hard. Cock: Hackle, saddle, shoulders and back, metallic black, sometimes mixed with chestnut. Bow of wing, black, mixed with chestnut. Wing-bar, green-black. Exposed web of flights, chestnut. Remainder of plumage, black. Hen: Black, partly striped with chestnut. Exposed web of flights, chestnut, slightly laced with green-black. Remainder of plumage, chestnut, with green-black lacing or edging, less definite on thighs and under parts, more definite on upper parts of body, especially the bars of the wing [**20**].

Malays. Comb, warty; has been described as resembling a half-walnut, red [**25**]. Eye, yellow or pearl. Beak, yellow or horn coloured. Face, wattles, and ears, red. Body, very broad in front, narrow behind, deep, full. Back, sloping downwards, the tail falling still lower at a wide obtuse angle. Carriage, gaunt; extremely tall, head being carried high; expression cruel. Large size. Legs and feet, very long, yellow.

Plumage. Cock: Feathers very short and hard. Hackle and back, dark red. Breast, under-feathering, and tail, rich black, the tail rather short. Wing-bar, metallic green-black. Hen: Dark. WHITES, pure snow-white. PILE, or PIED, closely resembling the pile game [**21**].

Aseel. Comb, pea shape, or triple, small. Eye, yellow or pearl, pink or white. Ears, small. Face and throat, red. No wattles. Body, short and wide, broad in front, narrow behind, hard. Legs and feet, stout and muscular, and, like body, lightly feathered, matching back in colour. Carriage, erect and angular, very hard and heavy.

Plumage. Close, tight, and hard. No fixed colouring, but there are BLACKS, REDS, WHITES, and RED and BLACK SPANGLES,

Brahmas. Comb, triple or pea [11, page 4857]. Face and ears, red. Wattles, full, rounded, red. Eye, red or pearl. Beak, dark yellowish horn, or yellow and black, short and strong; yellow in the light variety. Head, rather small and prominent over the eyes. Back, broad and short, the saddle gracefully rising to the tail. Breast, broad and prominent. Wings, medium. Tail, short, the feathering broad, and the coverts abundant. Legs and feet, orange or dusky yellow, heavily feathered to the ends of the three outside toes. Carriage, dignified and erect.

Plumage. DARK BRAHMAS. Cock: Head, hackle, saddle, back, shoulder, and outside web of flight feathers silvery white; hackle, striped with clear, dense black down the centre of each feather; saddle, the end of each feather densely striped with black, or the stripes may extend through the whole of the feather; wing-bar, lustrous green-black; tail, the curved feathers edged with white. Hen: Head and hackle, silvery white, the latter striped with dense black; tail black, the principal feathers edged with silver-grey; remainder of the plumage, pure silver-grey, each feather clearly marked with crescent pencillings of dark grey or grey-black.

LIGHT BRAHMAS. Silvery white, soft and abundant; the hackles sharply and densely striped with rich black; saddle of the cock slightly striped at the end of each feather. Tail, short; feathers broad and a lustrous green-black; the sickles laced with white; covert feathers of hen, laced with white.

Cochins. Comb, single, straight, and rather small. Face, ears and wattles, red. Eye, orange or pearl; in cuckoos, red; in blacks, red. Beak, yellow, shaded in partridges and cuckoos. Body, very deep, broad, and rounded. Back, short, gently rising to the tail. Wings, small and tight. Neck, short and heavily feathered. Tail, small, without sickle feathers; well supplied with coverts. Legs and feet short, abundantly feathered to the end of the middle toes, and yellow; dusky in the partridge variety. Carriage, massive, stately. The hens, gentle in appearance.

Plumage. BUFFS: Soft and mellow lemon buff, varying in shade in different birds, but uniform in each specimen. The pointed, glossy feathers of the cock, brighter and richer. The entire absence of black, white, and other colours than buff.

WHITES: Pure silvery white. [See 9, page 4856.]

BLACKS: Brilliant metallic black throughout.

PARTRIDGE. Cock: Metallic black throughout except hackle and saddle, which are orange-red striped clearly with black; back and shoulder, deep rich red; outside webs of the flight feathers, bay. Hen: Hackle, gold, striped to the end of each feather with black; rest of the plumage, rich brown, every feather marked with crescent-like pencilling of a much darker brown; legs and feet, dusky yellow; beak, horn or yellow.

22. BLUE-LACED ANDALUSIANS

CUCKOOS. Ground colour, a light grey slate. Every feather marked across with broad bars or pencillings of dark slate.

Langshans. Cock: Comb, single. Eye, dark. Ear, pendent, red. Face, red. Body, large and broad. Breast, deep. Back, long and well furnished. Wings, rather large. Neck, full. Tail, full and abundantly furnished, carrying a pair of sickles. Carriage, tall, upright, and alert. Hen: Body, gracefully rounded, carried well off the ground; absence of cushion. Tail, full. Other points as in the cock. Beak, in blacks, very dark horn; in whites, white; in blues, horn colour. Legs and feet, in blacks, dark grey; in whites, light grey. Toe-nails, white. [See 19, page 4859.]

Plumage. BLACKS. Brilliant metallic black.

WHITES. Glossy silver-white.

BLUES. Pointed male feathers of the cock, deep, rich, glossy slate; other plumage, slaty blue; the feathers definitely laced with dark slate to match the darker plumage.

Plymouth Rocks. Comb, single. Face, ears, and wattles, red. Eye, brown. Beak, yellow. Body, large and squarely built, with breadth and depth of breast. Tail, short, the curved feathers slightly more developed than in the Cochin. Legs and feet, yellow. Carriage, upright, proud.

Plumage. Ordinary steel-grey ground, every feather crossed with definite slaty black bars. This marking should cover the entire plumage. [See 12, page 4857.]

BUFFS. Rich buff of any shade, uniform throughout, more brilliant in the male feathers of the cock.

WHITES. Pure silver-white.

23. WHITE LEGHORNS

Wyandottes. Comb, rose [30]. Face, ears, and wattles, red. Eye, bay. Body, medium and well rounded, with full breast and short beak. Wings, medium. Tail, full and spread. Sickles, of medium size. Beak, horn, with yellowish tinge, with these exceptions—yellow

in whites and buffs, yellowish horn in buff laced. Legs and feet, yellow. Carriage, neat and symmetrical. The hen corresponding in all but male points. [See 13, page 4857.]

Plumage. GOLDENS. Cock: Golden bay, the centre feathers striped with black on the neck and saddle. The remaining plumage and the plumage of the hen, laced or edged as clearly as possible with lustrous black: tail, metallic black: the thighs and under-feathering, dark slate, imperfectly marked with golden bay.

SILVERS. Closely resembling the golden variety substituting silver for bay ground colour.

WHITES. Silvery white throughout.

BUFFS. Pure lemon or soft mellow buff of one tint throughout, the pointed or male feathers of the cock the most brilliant.

BUFF LACED. Similar to the buffs, but each feather laced with white, except in the pointed male feathers of the cock on the neck and saddles, which are buff, striped in the centre with white. The back, shoulders, and the bow of the wing, pure buff. Tail, white; under-colour, white. [See 4, page 4662.]

PARTRIDGES. Cock: Neck and saddle, orange, with a black centre stripe. Back and wings, red. Wing-bar, breast, and tail, black. Hen: Neck as in the cock. Tail, black, slightly pencilled at the ends of the feathers. Body plumage and wings, an even lightish blue; the feathers delicately pencilled with darker blue.

Orpingtons. Comb, single or rose. Face, ears, and wattles, red; red or brown in the buffs. Eye, black. Beak, black, but white or light horn colour in the buffs. Legs and feet, rather short and black. Body, full and deep, with broad chest and short back. Wings, closely carried. Tail, of medium size, well furnished. Carriage, bold and compact. [See 14, page 4858.]

Plumage. BLACKS. Metallic black throughout.

BUFFS. Rich buff of any tint, always uniform; the male feathers of the cock more brilliant.

Spanish. BLACK. Cock: Comb, large, erect, fine texture, the serrations clean-cut and uniform [28]. Hen: Fine, falling over. Face, very large, pure white, kid-like, reaching well over the eye and behind the ear, free from folds and large wrinkles. Ear, pure white, smooth, largely developed, deep and broad. Beak, dark horn. Wattles, long, red. Tail, large, full, flowing, nearly erect. Legs and feet, almost black. Carriage, upright, showy.

Plumage. Brilliant, glossy green-black.

Minorcas. Comb, single, large. Face and wattles, red, the former long. Ear, almond-shape, white, smooth. Eye, dark in the blacks; red in the whites. Beak, dark horn; white in the white variety. Neck, arched and full. Body, broad, square, compact, large as possible. Back, broad and long. Wings, medium and rather close fitting. Breast, full, rounded. Tail, full, with long, broad sickles. Legs and feet, medium black or dark slate. Carriage, upright, graceful, alert. The comb of the hen falls over to one side.

Plumage. Glossy metallic black or pure silver-white. [See 16, page 4858.]

Andalusians. Comb, large, single, red; in the hen large, falling over to one side. Face, red. Wattles, red, long. Ear, rather large, oval, white, smooth. Eye, red or orange. Legs and feet, clean, dark slaty black. Body and carriage resemble the Minorca, but slightly less compact; tail, full, flowing.

Plumage. Bright slate, every feather laced with dark slate or black, except the hackle, saddle, back, and other male plumage of the cock, which are very dark, glossy, velvety looking, slaty black. Tail, slaty black [22].

Anconas. Comb, single, erect, medium size, falling over in the hen. Face and wattles red; beak, yellow with dark shading. Legs and feet, yellow, mottled black. Body, compact, deep, broad. Tail, large, flowing, the feathers broad. Carriage, brisk and active.

Plumage. Brilliant green-black, mottled white, the white chiefly at the ends of the feather.

Leghorns. Comb, large, single, erect in the cock [29], falling over in the hen. Face and wattles, red. Ear, white, large, smooth, cream colour admitted. Eye, red. Beak, yellow in the whites and buffs; yellow or horn in other varieties. Body, wide in front, becoming narrow behind. Breast, rather prominent. Tail, full, gracefully carried, curved feathers, rather broad. Legs and feet, yellow or orange. Carriage, graceful, alert, dignified.

Plumage. WHITES. Silver-white throughout [23].

BROWNS. Cock: Neck hackle, orange-red, the feathers striped with black; breast and under-part of plumage, black; remainder of plumage, deep red, resembling the black-breasted red game, but less brilliant in colour; tail, black. Hen: Hackle, golden, striped black; breast, salmon; thighs, ashy; tail, black, in part brown pencilled: rest of plumage, brown, finely pencilled with darker shade. [See 1, page 4660.]

CUCKOO. Ground colour, bluish grey, the bars across each feather dark greyish blue.

PILE. Neck hackle, orange; saddle, maroon; shoulders and wing-bow, dark red. Breast, thighs, wing-bar, and tail, white. Hen: Neck hackle, white and gold, as in the Pile game. Breast, salmon; body, white.

GOLDEN DUCKWING. Cock: Neck hackle, straw colour; saddle, gold; back, deeper gold; shoulder, bright gold; coverts of the wing or bar, metallic blue-black; breast, under-parts and tail, black. Hen: Hackle, white, striped with black or very dark grey; breast, salmon; tail, grey; remainder of plumage, a dark greyish black pencilling on a lighter grey ground.

SILVER DUCKWING. Cock: Hackle and saddle, shoulders and wing, covert excepted, silver; wing, coverts or bar, blue-black; thighs, under-fluff, and tail, black. Hen: Hackle, silver, striped with black or very dark grey; breast and under-fluff, light salmon, shading off to grey; saddle and wings, a silvery grey pencilled with black or dark grey; tail, darker grey than the body.

Hamburghs. Comb, double or rose, rather small in the pencilled varieties, the spike long. [See 10, page 4857.] Face and wattles, brilliant red. Ear, white, smooth, round, the size of a shilling in the cock, and of a sixpence in the hen, except in the blacks, where it may reach the size of a florin. Eye, red in the pencilled and gold-spangled and black; dark hazel in the silver-spangled. Beak, horn in the pencilled and spangled; black or dark horn in the black variety; yellow or horn in the white and buff. Body, rather small and rounded. Hackles, full. Tail, long, the feathers broad, carried at right angles to the back, the side sickles or "hangers" abundant. Legs and feet, blue in all but the blacks, in which this colour is darker. Carriage, alert and jaunty.

Plumage. SILVER-PENCILLED. Brilliant silver-white ground. Cock: White throughout the exposed plumage, except the tail, which is metallic black, the sickles and secondaries or hangers delicately laced or edged with white. Hen: White neck hackle, the remainder of plumage marked with

green-black and almost mathematical bars across each feather from the throat to the tip of the tail.

GOLDEN-PENCILLED. Cock: Brilliant bright golden bay throughout, except the tail and hangers, which are metallic black, laced with golden bay. Hen: Golden bay ground throughout, the whole plumage, the neck hackle excepted, being pencilled or barred across every feather. [See 2, page 4661.]

SILVER-SPANGLED. Cock: Silver-white ground, every feather tipped with a bold green-black moon or spangle. Exceptions: The hackle, shoulder, and saddle of the cock are tipped with diamond spangles; the hackle of the hen is striped, the tail is white, with spangles at the end of each feather. [See 8, page 4856.]

GOLDEN-SPANGLED. Cock: Rich golden bay, marked as in the silver-spangled; the hackle of the cock, however, is well and clearly striped; the tail is green-black throughout.

BLACKS. Metallic black throughout, the sheen especially brilliant. [See 17, page 4859.]

WHITES. Silvery white throughout.

BUFFS. Buff of any rich, even shade throughout the plumage.

Redcaps. Comb, large, rose-shaped: spike, long [31]. Eye, red. Beak, horn. Face, wattles, and ears, red. Body, full, neatly rounded, broad. Tail, carried well up, curved feathers broad and long. Legs and feet, slate. Carriage, alert, graceful, jaunty.

Plumage. Cock: Hackle and saddle, red with a black stripe in the centre. Wing-bar, black; breast and under-fluff, black; tail, and all curved feathers, black. Hen: Rich brown-red, every feather well and uniformly spangled with a well-defined black half-moon.

Houdans. Comb, leaf-shape, the outer edges somewhat serrated, and to some extent antler-like [35]. Face and wattles, red. Ear, quite small, white or white and pink. Eye, red. Beak, light horn. Crest, large as possible, compact, globular. Beard, large, bell-like, and extending to the whiskers at the sides of the face. Body, broad, deep, of medium length. Neck hackle, full. Tail, long, full, the sickles and hangers broad and flowing. Legs and feet, slate or black and white, mottled. Carriage, alert.

Plumage. Mottled throughout, brilliant metallic black and white, evenly distributed, slightly darker in young birds; usually whiter after the first moult. The dark mottling preferred.

Crèvecœurs. Comb, two-horned, clean, finely pointed and right-angled [34]. Face, ear, and wattles, red. Eye, red or black. Beak, dark horn. Crest, large, globular. Beard, full and well formed. Legs and feet, black or deep slate. Body, large, square, deep, and rather long. Tail, large, flowing in the cock, the feathers broad. Carriage, the cock brisk, bold, and active; the hen, sedate.

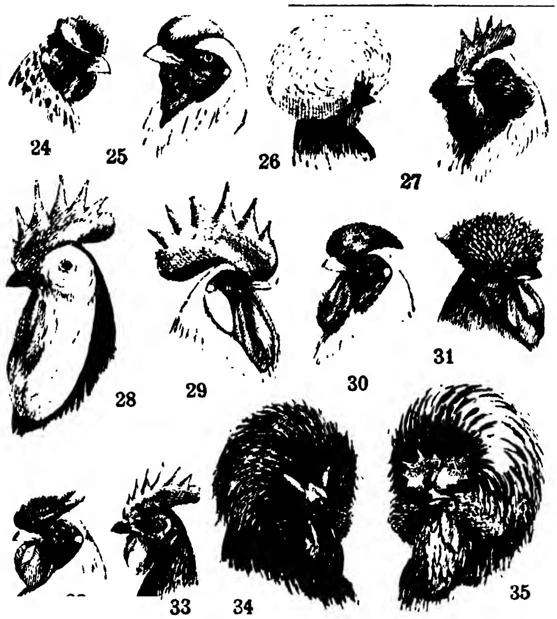
Plumage. Brilliant metallic black throughout.

La Flèche. Comb, two-horned (V-shaped), clean, round, symmetrical [15, page 4858]. Face and wattles, red. Beak, dark horn. Ear, large, rounded, white. Legs and feet, black or dark slate. Body, large, square, long, and thick. Tail, large and flowing, the curved feathers broad. Carriage, brisk and active. [See 18, page 4859.]

Plumage. Full, rich metallic black.

Faverolles. Comb, single, erect, even, serrated, medium size. Face, ear, and wattles, red. Eye, hazel or grey. Beak, horn or white. Beard and whiskers, black, with a little white [27]. Legs and feet, white, five-toed. Body, thick and characteristic of the table fowl. Tail, rather short, neatly curved.

Plumage. Cock: Hackles and wing-bows, straw-coloured; breast and wing-bar, black; beak and shoulders, black and white mixed with brown; tail and thighs, black. Hen: Whiskers and beard, a straw white; hackles, rich brown, striped with darker brown; back and wings, brown, the shade varying: tail to match; remainder of the plumage, cream.



THE VARIOUS FORMS OF COMB, CREST, AND BEARD

24. Cup comb (a fault) 25. Malay or warty comb 26. White crest 27. Beard and whiskers 28. Si[illegible] comb, white faced lobe 29. Oval ears 30. Curved rose comb 3[illegible] Rose comb 32. Double spike to rose comb (a fault) 33. Single [illegible] comb 34. Crest, beard, whiskers, and horned comb 35. Leaf [illegible]mb, crest, beard, and whiskers

Bresse. Comb, single, large, upright, falling over in the hen. Face and wattles, red. Ears, white. Beak, horn. Legs and feet, light slate. Body, medium, rounded. Tail, flowing; feathers, broad, medium length.

Plumage. Three sub-varieties, metallic black, white, and grey. In the grey Bresse the colour of the back is bluish and the feathers pencilled; the variety, however, is not yet bred to a standard.

There are other French varieties, the Barbezieux, the Mans, and the Courtes Pattes, which, among others, we described a quarter of a century ago after the great Paris Exhibition: but the French are very slow in breeding to any standard, and these so-called varieties are still much as they were.

Campines. Comb, single, erect, falling over in the hen. Eye, nearly black. Face and wattles, red. Ears, almond-shaped. Carriage, erect, alert, graceful.

Plumage. Hackle, white. Saddle of cock, white, with somewhat indefinite pencilling. Tail, black, the curved feathers mackerel-marked on each edge; remainder of plumage pencilled, as in the Silver-pencilled Hamburgh. The size and character of marking in course of transition.

GOLDEN CAMPINES. Resemble the whites or silvers, except that the ground colour is golden bay.

Scotch Greys. Comb, single, straight, medium size. Face, ear and wattles, red. Eye, red. Beak, white or white streaked with black. Legs and feet, white, or with a little black. Body, broad, deep, and substantial. Tail, flowing, medium length, the feathers broad. Carriage, graceful, erect.
Plumage. Bluish grey ground, every feather evenly crossed with dark greyish blue bars.

Scotch Dumpies. Comb, single, upright, medium size in cock. Eye, red. Beak matches the legs. Face, wattles and ears, red. Body, broad, very deep—this point is marked—square. Carriage, heavy, owing to the depth of body and shortness of legs. Tail, full, long, sickles flowing. Legs and feet very short, white in darks and silvers; black or slate in blacks; mottled in cuckoos.
Plumage. Black, cuckoo, or resembling the Dark and Silver-grey Dorkings.

Polish Varieties. Cock: Crest, very large globular, and compact. Comb, two tiny horns, but unnecessary. Face and wattles, red. Ears, white, tinged blue; exception, in white and white-crested blues and white-crested blacks, ear lobes white. Eye, red. Beak, horn or dark blue; exception, in whites and white-crested blacks and blues, dark blue. Body, rather deep, long. Breast, well rounded, and wings large. Tail, rather full and open. Legs and feet, medium length, fine, clean, dark blue, approaching black in the white-crested varieties. Carriage, proud, erect.
Plumage. SILVER-LACED. Cock: Crest, white, with black at the roots and tip: beard, laced: body plumage, silver; hackle feathers, tipped or spangled black; back and saddle, laced or spangled at tips of feathers; shoulders and wings, and rest of body, every feather clearly laced with black, the lacing rather broad. Hen: Crest, silver, black-edged throughout [**26**]; beard, laced or mottled: rest of plumage, silver, every feather black laced.
GOLDEN-LACED. Plumage resembling the silvers except that the ground colour is golden bay.
CHAMOIS OR BUFF POLISH. Cock: Crest, buff, white at roots and white-tipped: beard, buff, mottled or laced white: hackle, buff tipped with white; remainder of plumage, buff, except that the bars of wings and exposed web of flights, tail sickles and hangers are laced with white. Hen: Buff, white-edged: beard, resembling that of cock; hackle and rest of plumage, buff, white-edged.
WHITE-CRESTED BLACKS. Crest, white, like a snowball; remainder of plumage, metallic black.
WHITE-CRESTED BLUES. Crest, large and white: rest of plumage, dark blue. [See **6**, page 1855.]
WHITE POLISH. Snow-white throughout.

Sultans. Comb, two very small spikes buried in the crest. Crest, large, round, compact. Beard and whiskers full. Eye, red. Back, white or light blue. Comb, face, ears, and wattles, red. Body, deep. Breast, prominent. Beak, short. Tail, broad, well carried, long, flowing. Legs and feet, light blue, five-toed: the feathers of the thighs, vulture-like. Carriage, compact, Polish-like.
Plumage. Abundant, snow-white.

Silkies. Comb, wart-like, purple. Eye, black. Beak, slaty. Face and wattles, dark purple. Ears, light blue; skin, violet. Body, full, short, rather broad. Legs short; feet, five-toed, lead colour. Carriage, quaint, and yet graceful.
Plumage. White, soft, silk-like, fluffy.

Frizzled Fowls. Comb, rose-shaped. Body, quaint in appearance and small in size.
Plumage. Black, white or brown, every feather being curled, the tail excepted.

Old English and Modern Bantams. GAME. Points in all respects as in the large breeds. Exceptions in modern game: cockerels, not to exceed 20 oz., cocks, 24 oz., pullets, 18 oz. Old English game: outside weight of cocks, 22 oz., hens, 20 oz.
BLACKS. Comb, rose. Face and wattles, red. Ear, perfectly round, smooth, white, the size of a sixpence as a minimum. Breast, broad, very prominent. Wings, slightly drooping. Tail, full; feathers broad, carried back. Legs and feet, rather short, black.
Plumage. Metallic green-black. Weight, maximum, 16 oz. Hen: smaller in proportion in size in comb and ear.
WHITES. Beak, white. Eye, red. Legs, white.
Plumage. White throughout. In all other points resembling the blacks.

Sebrights. SILVER-LACED. Comb, rose. Beak, horn or dark blue. Eye, black, or nearly black. Face, wattles, and comb, dull red or purple. Ears to match. Legs and feet, blue-slate. Body, prominent and bold in breast, short back, wings drooping. Tail, square, spread. Carriage, short and strutting. Weight of cock, 21 to 22 oz.; of hen, 18 oz.
Plumage. Silver-white ground throughout, every feather sharply and distinctly edged or laced with metallic green-black. The cock's plumage resembles that of the hen, without male feathers.
GOLD. Beak, dark horn.
Plumage. Ground colour, golden bay. In other respects resembling the silvers.

Pekin Bantams. Pekin Bantams are tiny birds and closely resemble the Cochin China. Comb, small, single. Eye, red or orange tending to be golden in the buffs and blacks, red in the cocks. Beak, yellow. Dark shading in the partridge, black with yellow edges in the blacks. Face, wattles, and ears, red. Body, deep, short, and thick. Breast, full. Back, short, rising at the saddle into the short, full tail. Legs and feet, short, heavily feathered to the end of the middle and outer toes, yellow. Carriage, resembling that of the Cochin. Weight, 30 to 33 oz.; hens, 27 oz. to 28 oz.
Plumage BUFF PEKINS. Rich, even, lemon, or orange-buff. The Partridge resembles the Partridge Cochins as closely as possible.
WHITE. Snow-white.
BLACK. Rich, glossy black.
CUCKOOS. Resemble the Cuckoo Cochins.

Booted Bantams. Comb, single. Face, ears, and wattles, red. Eye, red; in the blacks, dark red or brown. Beak, white; in the darks, black or dark horn. Body, compact. Breast, prominent. Feathering, long. Tail, large, abundant, almost upright. Legs and feet, white: in the blacks, black. Carriage, strutting. Weight of cocks, 23 oz. to 25 oz.; hens, 18 oz. 20 oz.
Plumage. White in the white and whiskered varieties, black in the blacks. Heavily feathered to the tips of middle, and outside toes.

Other Varieties of Bantams. The Frizzled, Andalusian, Aseel, Indian Game, Malay, Polish, Spanish, Minorca, Leghorn, Hamburgh, Sultan, Scotch Grey, and Brahma Bantams, closely follow the varieties of which they are diminutive imitations. The Japanese bantams are very short in body and leg. They have dropping wings, and are bred in several colours. There are whites, blacks, greys, and buffs. The curved tail feathers in the whites are black, sharply laced with white around edges. Comb, single and large. Beak, yellow. Face, wattles, and ears, red. Legs and feet, yellow.

Continued

FOOD CROPS

Temperate and Tropical Root Crops. Stimulants and Narcotics. Tea, Coffee, and Cocoa. The Pulses. The Sugar Cane

Continued from page 4876

By Dr. A. J. HERBERTSON, M.A., and F. D. HERBERTSON, B.A.

ROOT crops play a great part in temperate agriculture. The most important are the potato, a staple food in temperate lands, turnips and mangels for stock, and the sugar-beet.

Potatoes, Turnips and Mangels. The potato, a native of South America, is now cultivated from the tropics to the Arctic Circle. Its cultivation became important in Ireland by the end of the seventeenth century. Thence it spread to Lancashire, and had become general in the British Isles by the middle of the eighteenth century. It became popular in France, Germany, and other parts of Europe by the end of the eighteenth century.

The potato crop is very liable to disease; too exclusive reliance on it may mean famine, as in Ireland in the middle of last century. The production per head is greatest in Ireland and Germany. In North Germany the potato is the chief food of the working classes, but a large proportion of the crop is used for distilling a cheap spirit. Starch is largely manufactured from potatoes.

Many varieties of potatoes are cultivated. New ones are constantly introduced, and, like the famous Northern Star a few years ago, may for a time command fabulous prices. Except in such cases, the potato is too bulky to pay for long transit, and the trade is chiefly between neighbouring countries. Early potatoes, which fetch big prices, are imported from Malta, France, and the Channel Islands especially. They are grown for the American market in the Bermudas. [See AGRICULTURE, page 1665.]

Turnips and mangel wurzels, a species of beet, are largely grown as a field crop for feeding stock. The turnip has long been grown in India, and is cultivated as a vegetable in most parts of the cool temperate zone. As a field crop it became important in Britain about the end of the seventeenth century, and marked a new era in agriculture by improving the rotation of crops, and by supplying winter food for stock, so that fresh meat became available all the year round. It is comparatively little used for this purpose in North America, where the climate does not suit it. Like the potato, it is too bulky to bear the cost of transport.

Beet Sugar. The cultivation of the sugar-beet, now so important on the poorer soils of North and Central Europe, dates only from the continental wars of a century ago, when French ports were closed to tropical produce. The cultivation of sugar-beet has led to a fall in the price of sugar and a vastly increased consumption, especially among the Teutonic races. In 1840, when beet sugar formed only about four per cent. of the world's produce, the average consumption per head in this country was 15 lb. per annum, while now, when beet sugar forms approximately half of the world's production and two-thirds of the commercial article, it has increased to six times that quantity [see Sugar in FOOD SUPPLY, page 4047].

Cane sugar needs less labour in cultivation, is richer in sugar, involves less costly machinery, and is grown where labour is cheap. Beet sugar requires annual planting, a high state of cultivation, considerable expense in fertilisers, expensive processes of manufacture, and is carried on where labour is dear. On the other hand, it has the advantage of proximity to markets, and the refuse forms a valuable feeding-stuff for cattle. It is much more widely cultivated in Europe than in the United States, where it is grown in California and Michigan. Germany produces beet sugar to the value of about £15,000,000, Austria-Hungary £10,000,000, France £8,000,000, and Russia £9,000,000. The total value of all the beet sugar produced in the world is about £55,000,000.

Tropical Root Crops. Few tropical root crops are commercially important. Manioc, or cassava, a native of Brazil, is widely cultivated throughout the tropics. It is propagated by cuttings, and needs almost no attention. In its preparation a poisonous juice must be extracted by heat before it is fit for food. In South America the dried and grated root, known as *farinha*, is a staple food. Tapioca, a preparation of manioc, is imported into this country from the West Indies, and from the East Indies through Singapore. Much so-called tapioca is in reality only potato starch.

Arrowroot is a highly digestible starch extracted from the roots of various tropical plants. It is obtained from both the East and West Indies, but the finest comes from Bermuda and Jamaica.

Two other tropical roots, though of no commercial value, may be mentioned, the yam and taro. The yam is an important food in the West Indies and other tropical regions. Its roots, which are rich in starch, attain the weight of 30 lb. in some of the Polynesian species. Taro, widely cultivated in the Pacific islands, is an edible root of a species of arum. It is boiled or ground into a species of meal. Its leaves serve as a vegetable.

Ginger has long been cultivated for its pungent root in the East Indies, and is now also cultivated in the West Indies and West Africa. The root stock, the ginger of commerce, is scalded and dried. Preserved ginger, a sweetmeat made by preserving the young root in syrup, is exported from China and the East and West Indies.

Stimulants and Narcotics. Stimulants and narcotics include hops, tobacco, opium, tea, coffee, cocoa, and others of less importance. Hops are chiefly used for imparting a bitter flavour to beer. They are an expensive and uncertain crop. They require a rich, deep, well-worked soil, which they rapidly exhaust. They bear in the third year, but the crop is very liable to fail or be short. In 1906 the yield was only about 6 cwt. to the acre, against 13 cwt. in 1905. Kent, Surrey, Sussex, Hereford and Hampshire are the chief hop counties. On the Continent hops are extensively grown in Bavaria, which brews famous beers, Bohemia, and Alsace Lorraine. In the United States, California and Oregon grow most hops. Beer, the commonest beverage in Northern Europe, is made from barley or other cereals, which are malted by a process of partial germination which converts the starch into sugar. Water and hops are added, and the whole fermented. Germany leads in the production of beer, followed by Britain and the United States. Certain towns, such as Munich in Bavaria, Pilsen in Bohemia, Burton in England, or Milwaukee in the United States, acquire a special reputation, but brewing is carried on to a considerable extent in most large towns. [See Brewing in Food Supply.]

Tobacco. Tobacco, the leaf of a plant of the nightshade family, is a native of the New World, where, at the time of the European conquest, it was known from Canada to Patagonia. It was introduced into Europe in the fifteenth century, where its use was at first vehemently opposed. Its popularity makes it a favourite source of revenue. In several European countries the manufacture is a Government monopoly. The tobacco plant is cultivated from within 30° or 40° of the equator, where it does best, to the latitude of Southern Sweden. Tobacco requires protection against frost, a good, well-drained soil, and a moist, warm climate. The product is of varying excellence, according to the soil, climate, and method of preparation. The finest tobacco in the world is grown in certain districts of Cuba, and is made into the famous Havana cigars. Much tobacco is imported from the Philippines into Cuba, where the climatic conditions seem specially suitable for cigar-making. To avoid the heavy American customs duties, considerable quantities of Cuban tobacco are sent to Key West in Florida, and made into excellent substitutes for Havanas by Cuban labour, under climatic conditions very similar to those of Cuba. Porto Rico, Mexico, and Brazil all grow excellent tobaccos, though these are less in demand than that of the Philippines.

The quality of the Manila product ranks next to that of Havana. Sumatra tobacco is also of high quality, and its fine bright leaves are in great demand for wrapping. In the United States, which produces about one-third of the world's crop, tobacco is widely grown, but the southern states, and particularly Kentucky, lead. The great tobacco markets of the United States are Louisville, Ky.; and Richmond, Va. There is an immense import and re-export trade. Nearly all the snuff in use is made in the United States. The finest cigarette tobacco is grown in Asiatic Turkey. Tobacco is successfully cultivated in South Africa, Rhodesia, Uganda, British Central Africa, etc. In Europe it is grown in Austria-Hungary, Germany, Russia, the Balkan Peninsula and France. India is an important source of supply, though the product is not of the finest quality.

The annual value of the American tobacco crop is about £12,000,000, of India £6,000,000, and of Cuba, Russia, and the Dutch East Indies about £3,500,000 each. The value of the tobacco produced in the Philippines is about £500,000, a figure which will doubtless greatly increase with the development of the archipelago. The largest importing countries are Germany and the United Kingdom. The consumption per head is highest in the Netherlands and Belgium, where it is double that of Germany, and more than three times that of this country. [See Tobacco, page 4270.]

Opium. Opium is a dried juice obtained from the unripe capsules of the opium poppy, which is cultivated in India, Persia, China, Asia Minor, and Egypt. Opium, which possesses narcotic properties, is one of the most widely used drugs in the world. It is the source of laudanum and morphia, both largely used in medicine. Opium is much used as a stimulant and narcotic in China, by inhaling from a specially prepared pipe.

India is the chief support of the opium trade. In British territory its cultivation is a Government monopoly, permitted only in parts of Bengal, and of the United Provinces of Agra and Oude. The cultivator must sell his whole crop at fixed prices to Government agents, who forward it to the Government factories at Patna and Ghazipur. The product is sold by auction monthly at Calcutta for export to China. The proceeds form an important item in the Indian revenue, which also receives a contribution from the excise opium, or the opium consumed in India. Opium is grown in many of the native states of Rajputana and Central India, but it exported to China pays a heavy duty at the British frontier. The total net revenue from opium is slowly declining. In the ten years ending 1899 it was not far short of £4,000,000, but in the ten years ending 1904 it had declined to a little under £3,000,000.

The cultivation of opium, though nominally prohibited in China, is very general, especially in Szechwan. The present Chinese administration proposes to stop the cultivation and use of opium within a short period. Opium is also extensively grown in Persia for the Chinese market. The British supplies are chiefly drawn from Asia Minor.

Tea. Tea is a stimulant beverage obtained by infusing the dried leaves of an evergreen shrub of the camellia family, which is grown chiefly in the monsoon lands of Asia. Introduced into Europe in the seventeenth century, it has become a necessary of life to all classes, and is an important source of revenue. Until the middle of last century the world's supply of tea was almost

exclusively derived from China, where the tea shrub has been cultivated since the sixth century A.D. Early in the nineteenth century a variety was found wild in Assam, and experiments led to the rapid development of the tea industry. Tea is now extensively grown in the Himalayas, in the Nilgiri Hills of Southern India, and in Ceylon since the failure of coffee about 1881. In 1871, out of about 124,000,000 lb. used in this country, 110,000,000 lb. came from China, and only 14,000,000 lb. from India. By 1901 the position of 1871 was reversed, China supplying only 17,000,000 lb., while India and Ceylon supplied 238,000,000 lb., of which India furnished 148,000,000 lb. The introduction of Indian tea has led to a rapid fall of prices and a greatly increased consumption.

Where the Tea Plant Thrives. The tea plant has a considerable climatic range, and is hardy enough to resist occasional frost. It prefers a warm, moist climate and a rich, well-drained soil. New plantations in India and Ceylon are generally on mountain edges, where good drainage is ensured, where the soil is rich in vegetable mould, and where water power is available for the machinery which has replaced hand labour in the younger tea countries. Tea is grown up to 7,000 ft. in Darjiling and Ceylon. Growth is more rapid at lower elevation, but that grown at high elevations has a special delicacy of flavour. The average yield is from 300 to 500 lb. an acre, but in favourable situations and seasons it may exceed 1,000 lb. The Assam plant grows to the height of 50 ft., and has a large leaf The Chinese tea plant is a low shrub, with smaller leaves. A hybrid of the two is generally cultivated in new plantations.

There are many varieties of tea on the market, due to variations in the climate and soil, the season of picking, the size of the leaf, and the method of preparation. The latter, including labour, requires, it is computed, a man's labour for a day to prepare a pound of tea. Tea, therefore, can be profitably grown only where labour is abundant and cheap, and for this reason, rather than climatic causes, it is practically confined to the monsoon lands. Picking is everywhere done by hand, and in full season a good picker can gather from 20 lb. to 30 lb. a day. In India and Ceylon, the picking takes place every few days. In the latter, where there is practically no winter, tea is produced almost all the year round. In China the subsequent processes are done by hand or foot, but in India and Ceylon machinery is used, as cleaner, quicker, and more efficient. The tea is graded and packed in chests lined with sheet lead or in airtight packages. Brick tea is moulded under pressure. The cheaper grades of brick tea consist chiefly of refuse, and are sent to Tibet and other parts of Central Asia.

Tea is also grown in Japan (chiefly exported to the States), Java, Brazil, Transcaucasia, the south-east of the United States, Jamaica, Natal, and Madagascar.

How Tea is brought to Europe. The routes followed by the tea trade have been greatly modified in the last half-century. Before the opening of the Suez Canal tea for Western Europe came round the Cape in special fast clippers. It now comes by the Suez Canal. The finest teas for Western Europe, and for Russia, are forwarded by the Siberian line, as an ocean voyage somewhat injures the flavour. The American tea formerly went by the Suez Canal and the Atlantic, but is now forwarded to the Pacific ports, and sent overland to the market of the East.

The British Empire is the largest consumer of tea. The consumption in Australia exceeds 7 lb. a head; in the United Kingdom it is over 6 lb., and in Canada, 4 lb. Holland, the largest consumer outside the British Empire, uses only 1½ lb. a head.

The so-called Paraguay tea, or yerba maté, which also grows in Southern Brazil, consists of the leaves of a species of holly. Its stimulating properties resemble those of tea. It is much used in South America, but is in no demand in Europe.

Coffee. Coffee, with similar stimulating properties, is obtained by drying, roasting, and grinding the seeds or beans of a tropic shrub of the same family as the cinchona. This attains a considerable height when wild, but is pruned to a bush under cultivation. It bears a red berry not unlike a cherry, which contains one or two seeds. These are first pulped and then dried, a less good result being obtained if these processes are reversed, as in Brazil. The seeds are then deprived of the endocarp, cleaned, and sorted, processes in which machinery is now largely used. The quality of coffee depends partly on age, partly on the mode of sorting. Java coffee, formerly a Government monopoly, used to be seasoned for several years. Machine sorting, as practised in the New World, secures a uniform size, but does not reject bad berries. The famous Arabian coffee, still called Mokha, though the market is now Hodeida, is hand-sorted, and in Cairo and Constantinople fetches an enormous price. The finest never reaches Western Europe.

The Home of the Coffee Plant. The coffee plant is less hardy than tea, and is very sensitive to frost. It is chiefly grown within the tropics, but near the equator, where the lowlands are too hot, it is grown up to 6,000 ft. Generally the range is up to about 3,000 ft. Mountain slopes cleared of trees suit it well in suitable latitudes. The young plants require shade, and bananas and other frail trees are grown for this purpose. The plant is probably a native of Abyssinia, where it has long been cultivated. It was introduced into Arabia in the fifteenth century, and became generally known in Europe in the seventeenth century. In 1650 the Dutch introduced it into Java, and in the eighteenth century it was introduced into the West Indies and South America. The Brazil provinces of Rio Janeiro and São Paulo are now the great source of the world's coffee, producing over 16,000,000 lb. annually, valued at over £20,000,000. The other coffee-producing lands are Colombia (70,000,000 lb.), Java, Venezuela, Guatemala, India, where it is grown in the cleared slopes of the Western Ghats, Ceylon,

where the cultivation is now insignificant, Mexico, Porto Rico, Salvador, Costa Rica, Arabia (11,000,000 lb.), Haïti, West Africa, and the Shiré Highlands. It has also been successfully introduced into Queensland. The Liberian plant, though inferior in flavour, withstands the leaf fungus better, and is now being introduced into Ceylon and elsewhere. The chief coffee-importing countries are the United States (871,000,000 lb.), Germany (370,000,000 lb.) France (185,000,000 lb.), Holland (103,000,000 lb.) and Austria-Hungary (97,000,000 lb.). Holland is the largest consumer ($14\frac{1}{2}$ lb. per head), Norway, Sweden, the United States and Belgium consume over 10 lb., while the consumption per head in this country is under $\frac{3}{4}$ lb.

Coffee is frequently adulterated with chicory, parched grain, pease, etc. Of these, chicory is the least objectionable.

Cocoa. Cocoa, or to be correct, cacao, is obtained from the seeds of a tropical tree indigenous to Mexico and tropical America, where it was in use at the time of the European discovery. It requires a hotter climate than coffee, a deep, rich soil and abundant moisture. If grown under shade it is well suited to the tropical lowlands. It is chiefly grown in Ecuador (market, Guayaquil), Venezuela (market, Caracas), Brazil, some of the West Indies, Ceylon, and Java. The large, bright, fleshy pods are allowed to ferment, and are then dried in the sun. When roasted and split, they are known as *cocoa nibs*. The flesh is rich in nutritive as well as in stimulating properties. It contains a large proportion of fat (cocoa butter) and starch. The former is extracted in the manufacture of chocolate and cocoa. The latter is frequently adulterated by the addition of a large quantity of starch. Chocolate is the favourite beverage in Spain, where it was early introduced by the Spanish conquerors. It is also much used in France.

Coca and Kola. To these stimulants may be added coca and kola. Coca is the leaf of a shrub indigenous to South America. It is said to render exertion easy, even with scanty food and sleep, and facilitate respiration at high altitudes. It is consequently highly valued by the Indians of South America. It forms an ingredient in some tonic wines. Cocaine, an alkaloid obtained from it, is used as a local anæsthetic. The kola nut, the seed of a West African tree now cultivated in Mauritius, the West Indies, and tropical America, is similarly used in the Sudan and other parts of Africa. In Europe it is employed as a tonic and as an ingredient in some cocoas.

The Pulses. The pulses, or pod-bearing plants, are represented in this country by the pea and bean. The *pea* is suited to the cooler parts of the temperate zone, and is imported into this country from Denmark and North America. The *chick pea*, cultivated in Southern Europe, India, and tropical South America, is an important article of food and trade in this region. The *bean* has many varieties suited to different climates. It is used both as food and fodder. The beans imported into this country come from Egypt and Mediterranean countries. *Soya beans* are an important crop in China, Japan, and India. Lentils are grown in Germany, Southern Europe and Egypt. The *carob*, or locust, is imported from Cyprus and Portugal, chiefly as cattle food. Various pulses are grown as fodder plants in this country, and still more in the Mediterranean and other regions with dry summers. *Alfalfa*, or *lucerne*, one of the more important, has deep roots adapted to a dry climate, and is extensively grown round the Mediterranean and in the drier parts of North and South America. [See AGRICULTURE.]

Sugar Cane. Until the beginning of the nineteenth century the world's supply of sugar was derived wholly from the sugar cane, a member of the grass family, somewhat resembling maize in its unripe state, and yielding, under pressure, a strongly saccharine juice. The European discoverers of the New World introduced the sugar cane into the West Indies and the adjacent mainland, where it was grown on a large scale by slave labour. The abolition of slavery, and the competition of beet sugar under a system of bounties, has led to a decline in the sugar cane industry, especially in the West Indies. [See FOOD SUPPLY, page 3652.]

Except in the basins of the Amazon and Congo the sugar cane, which requires heat and moisture, is widely grown within 34° of the equator. India and China are large producers, but export little. Cuba, Java, the Gulf Coast of the United States, Mauritius, the Philippines, and Hawaii are the chief sources of the commercial supply. The cane is also cultivated in Natal and tropical Australia. The yield per acre varies from 10 or 12 tons up to 34 in Hawaii.

A liquid residuum formed during manufacture is known as *molasses*, and is used for making rum and for other purposes.

The Enormous Consumption of Sugar. Sugar, a costly luxury little more than a century ago, is now almost a necessary of life, and a valuable article of diet. The consumption among the Teutonic races is very large, a considerable proportion being in the form of jam and confectionery. In Australia the annual consumption reaches $101\frac{1}{2}$ lb. a head, in New Zealand $96\frac{3}{4}$ lb., in the United Kingdom $88\frac{1}{2}$ lb., and in the United States $68\frac{1}{2}$ lb.

All the agricultural crops hitherto described are food-stuffs. The groups treated in the next article include those of industrial importance. These are the fibre plants, the oil seeds, dyeing and tanning materials, drugs and miscellaneous useful plants.

Continued

Continued from page 4849

SOAP

By John McArthur

Soap, in a strictly chemical sense, is a general term applied to salts of fatty acids, or compounds formed when a base combines with a fatty acid. Industrially, however, the term is restricted to the compounds of the alkalies potash and soda and fatty acids.

The art of soap-making dates from very early times. Pliny, in the first century, describes a crude soap made from goat's tallow and the ashes from beech-trees; while among the ruins of Pompeii, destroyed by an eruption of Mount Vesuvius in 79 A.D., some soap and the remains of a soap-making establishment have been discovered. In early times various oils and fats were saponified by treatment with the alkaline ashes of wood and seaweed, but with the introduction of Leblanc's process for the manufacture of soda [see Alkalies] and the discovery of the constitution of fatty bodies by Chevreul, the industry was placed on a scientific as well as a practical basis, and has now assumed immense proportions in all the civilised countries of the world.

Properties of Soaps. Soaps are known as *Hard* (soda) soaps and as *Soft* (potash) soaps, according to the base employed. They are easily soluble in water and in alcohol, their aqueous solutions possessing characteristic lathering properties. When solutions of hard soaps are mixed with salt (sodium chloride) the soap is precipitated; but in the case of soft soaps the action is different, a double decomposition taking place, whereby a soda-soap is formed, and potassium chloride remains in solution. The detergent power of soap is generally understood to be due to the hydrolysis taking place in presence of water, when the soap is partially decomposed with formation of an acid-soap and free alkali, the latter enabling the water to come into intimate contact with the surface, by removing the greasy film which resists the action of the water alone. The cleansing power of soap has also been explained by the inherent property—which soap solutions possess—of emulsifying fats, and thus releasing the foreign matter.

1. STEEL SOAP FRAME
(W. J. Fraser & Co.)

Raw Materials. The most important fats and oils used in the manufacture of hard soaps are tallow, various greases of animal origin, lard, coconut oil, palm oil, palm-kernel oil, cottonseed oil, etc., as well as resin and fatty acids. For soft soaps vegetable oils are generally used, such as cottonseed, linseed, olive, etc., and sometimes the fatty acids derived from these oils; also the better qualities of fish oil. The fatty acids are sometimes obtained by the hydrolysis of the fat by the Twitchell process, referred to in discussing Candles. It has been recently shown by W. Connstein and others that it is possible to hydrolyse glycerides by the ferment, or enzyme, present in castor seed, by allowing it to act upon the glyceride kept in a state of emulsion by slightly acidulated water. This fact has been utilised industrially for obtaining fatty acids of good colour from such liquid oils as cottonseed, linseed, etc., with the object of employing the fatty acids in the making of soap and recovering the glycerin.

The alkalies are used in the form of a strong solution, or "lye," of the hydrate of the respective base, soda or potash. Many manufacturers, instead of dissolving the solid caustic soda for the purpose, find it more economical to causticise a solution of carbonate of soda, or soda-ash, by means of lime, and concentrate the solution to the required strength in vacuum evaporators. The reaction taking place is represented by the equation:

$$\underset{\text{Sodium carbonate}}{Na_2CO_3} + \underset{\text{Slaked lime}}{CaH_2O_2} = \underset{\text{Sodium hydrate}}{2NaHO} + \underset{\text{Calcium carbonate}}{CaCO_3}$$

Silicate of soda, carbonate of soda, and borax are sometimes employed to increase the detergent properties of hard soaps and to harden them: and a neutral salt, such as sulphate of soda, is often added for the latter purpose, as well as to add weight.

Making Hard Soaps. The process of saponification of oils and fats by alkalies for the production of soaps depends upon the conversion of the glycerides into salts of the alkali metals, glycerol being eliminated. This is shown by the following equation, which represents the reaction with tri-stearine (the principal glyceride present in tallow) and caustic soda:

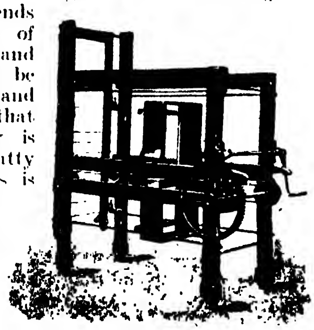
$$\underset{\text{Tri-stearine}}{\left.\begin{matrix} C_3H_5 \\ (C_{18}H_{35}O)_3 \end{matrix}\right\} O_3} + 3\underset{\text{Sodium hydrate}}{\left.\begin{matrix} Na \\ H \end{matrix}\right\} O} = 3\underset{\text{Sodium stearate}}{\left.\begin{matrix} Na \\ C_{18}H_{35}O \end{matrix}\right\} O} + \underset{\text{Glycerol}}{\left.\begin{matrix} C_3H_5 \\ H_3 \end{matrix}\right\} O_3}$$

The principal methods of effecting saponification are:

1. By the direct neutralisation of fatty acids by a solution of caustic, or carbonated alkali, oleic acid being generally used.
2. By heating the neutral fat and alkali, in presence of water, in a closed boiler, or *autoclave*, under pressure.
3. By the *cold* process, consisting in acting upon the neutral fat with an adjusted quantity of alkaline lye just sufficient to effect the saponification.
4. By the *boiling* process, in which the neutral fat is first saponified with a comparatively weak solution of caustic soda, the soap "salted out," to be afterwards finished, and the glycerin separated.

The last two processes named, which are those most extensively used, will now be briefly described.

The Cold Process. This process possesses the advantage of simplicity, and can be carried out with small quantities of material and with inexpensive plant. The vessel in which the process is conducted consists of a steam-jacketed pan, provided with a mechanical agitator. The fatty matter, preferably coconut oil or tallow, or a mixture of the two, is heated to about 35° to 45° C., and strong caustic soda lye, of 1·25 to 1·35 specific gravity, gradually added, while the mass is thoroughly mixed by continuous agitation. The strength of the lye depends upon the nature of the fatty matter, and the quantity must be carefully measured and be adjusted so that only a sufficiency is used for the fatty matter. The mass is then run into a shallow wooden frame, and covered up so that the heat may be retained; the temperature meanwhile rises, and the saponification becomes complete in about twenty-four hours. It is obvious that the materials used must be of the best quality, as any impurities present necessarily remain in the soap; the glycerin, eliminated from the fatty matter, is also present in the finished soap. Soaps made by this process are liable to contain a slight excess of free alkali, or of neutral fatty matter, and are not generally of the finest quality.



2. SLABBING MACHINE

The Boiling Process. This process is by far the most important of those referred to: it serves for the manufacture of the great bulk of the soaps generally met with, and yields products superior in quality to those obtained otherwise.

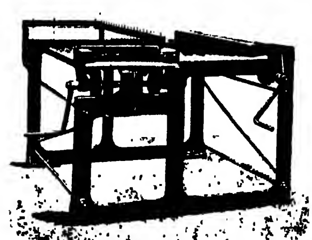
The iron vessel, known as *soap-copper, soap-pan,* or *kettle,* in which the saponification is carried out, is generally cylindrical in form, and capable of making 30, 60, and even 100 tons of soap. It is provided with two coils, one perforated, for supplying "open" steam, the other closed, for "close" steam. The fatty matter is first boiled with weak soda-lye, and the boiling continued until a sample on examination appears somewhat firm, and has only a faint caustic taste. Considerable experience is required to know when the first stage of the process has been completed, and, indeed, this remark applies to the successful carrying out of all the details of soap manufacture. With the object of separating the partially formed soap from the excess of water, from the glycerin derived from the fatty matter, and from the impurities of the alkali, salt, in the solid state or as strong brine, is added to the contents of the copper, when the soap rises to the surface as a more or less granular, curdy mass. This part of the process is known as *graining* or *cutting* the soap. The lower layer or "spent lye" is removed, and treated separately for the recovery of the glycerin and of the salt [see Glycerin]. The granulated soap is then boiled with water and fresh lye, in order to complete the saponification of the fatty matter, and the "half-spent" lye is removed after settling, and may be used for the saponification of another quantity of fresh fat. The contents of the copper are boiled once more with free steam and added lye, to ensure complete saponification, this operation being known as *making* the soap.

Three qualities of "boiled" soap are generally recognised, known respectively as *curd, mottled,* and *fitted,* the distinction depending mainly upon the manner of the treatment of the soap subsequent to the various operations just described.

Curd and Mottled Soaps. For the manufacture of these varieties, when the soap has been "made," the boiling is continued by means of close steam, in order to concentrate the lye, and the soap is removed after settling. Tallow is generally used for the best quality of curd soaps. Genuine mottled soaps are made from darker fats than those employed for curd soaps, such as melted fats, bone fats, etc. Their characteristic appearance, from which they derive their name, is due to the presence of impurities in the materials used, which segregate as the mass cools. It is a common practice to produce artificial mottling of soaps of this class by the introduction of oxide of iron, ultramarine, etc. When a solution of silicate of soda is added, as well as of other salts, a hard soap may be obtained, although as much as 50 per cent. of water may be present, or more than double that contained in a genuine mottled soap, needless to say, to the serious loss of the user. In justice, however, to the honest manufacturer, it should be stated that in many cases the demand for cheap soaps has compelled him to place upon the market products of inferior quality, which he cannot conscientiously recommend. Mottling cannot now be always regarded, as it was some fifty years ago, as an indication of good quality.

The practice of *liquoring,* or *silicating,* is by no means confined to soaps of the mottled description. Mottled soaps are largely used for laundry work.

Fitted, or Yellow Soaps. The best qualities of soaps of this class are made from tallow of good colour, and the inferior qualities from dark coloured tallow, greases, etc., resin being an essential component of both qualities. When the soap has been "made," as already explained, the contents of the copper are allowed to stand for some hours, the lye run off, and the whole boiled with more lye, if necessary, to "fit" the soap, so that, while it contains the proper proportion of water, it may still be sufficiently "open" to allow the impurities to settle out. The mass is then allowed to stand for some days, when a separation into three layers takes place—a soapy scum or "fob" on the surface, which can be worked up in the next batch of soap; the finished, or "neat" soap in the centre, which is removed for cooling; and the "nigre," or dark-coloured alkaline lye underneath, which can be utilised for the making of soaps of dark colour.

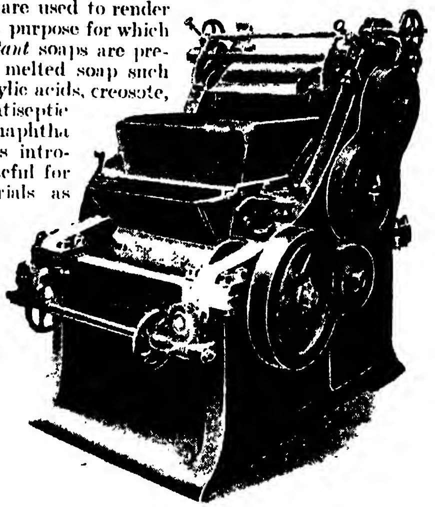


3. BARRING AND TABLETTING MACHINE

In England, under the general designation of *washers,* but distinguished by various fancy names, there have been recently introduced certain yellow soaps, made principally from cottonseed oil, and generally smaller proportions of tallow, coconut oil or palm-kernel oil, and resin. These have an

extensive sale, and are preferred in many households to ordinary yellow soap on account of their ready lathering properties.

Other Varieties of Hard Soaps. There are many varieties of hard soaps, in the preparation of which certain ingredients are used to render them suitable for the specific purpose for which they are intended. *Disinfectant* soaps are prepared by crutching into the melted soap such materials as carbolic and cresylic acids, creosote, and other disinfectant and antiseptic agents. In the same way, naphtha or paraffin oil is sometimes introduced, the product being useful for laundry work. Such materials as sand, silica, fullers' earth, powdered pumice, etc., are often incorporated with the melted soap, the mixtures yielding, on cooling, more or less hard blocks, which are serviceable for the cleaning and polishing of metallic surfaces and for the cleansing of greasy paint, kitchen utensils, etc. *Marine* soaps, which can be used with sea-water, are products prepared by the cold process from coconut oil and caustic soda, and often contain little genuine soap. *Cold water* soaps, which are supposed to possess the advantage of lathering freely with cold water, are often hardened by the addition of silicate and carbonate of soda, and are generally of inferior quality and wasteful in use. Besides those mentioned, special soaps are also made for manufacturers' use, such as for the scouring of wool, yarn, and cloth, and the "milling" of woollen goods; the washing of printed calico; in the dyeing of cotton and silk goods, etc.

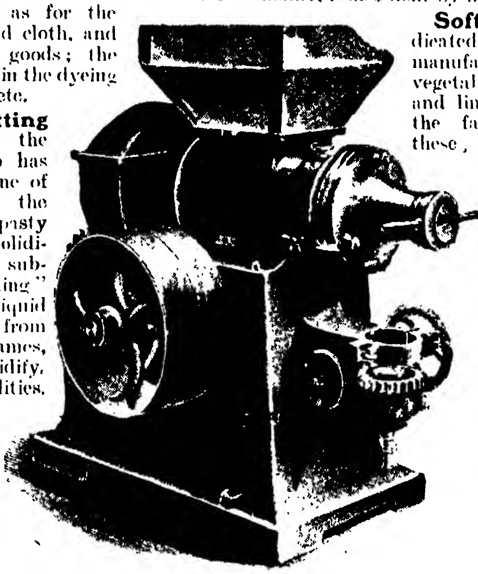


4. MILLING OR CRUSHING MACHINE
(A. Saalfeld & Co.)

Framing and Cutting Hard Soaps. When the manufacture of the soap has been completed by any one of the processes described, the product is obtained as a pasty mass, which, on cooling, solidifies to a somewhat soft substance. When no "filling" agents are added, the liquid soap is run, or pumped, from the copper into cooling-frames, where it is allowed to solidify. In the case of inferior qualities, the soap is first mixed with solutions of the salts, as required. The cooling-frames are capable of holding from 10 cwt. to 15 cwt. of soap, although in certain cases it is preferable to have them much smaller. They are of two kinds. Where slow cooling is desirable, as in the case of mottled soaps, they are made of wood, but cast iron and steel frames [1] are more convenient, and are more extensively used. The frames are constructed so that when the soap has become solid, the sides can be removed, when the rectangular block of soap remains, to be afterwards cut into slabs, and these again into bars.

The cutting into slabs is sometimes done by hand, a thin wire, in the form of a loop, being drawn horizontally through the block of soap along parallel lines, the position of which has already been marked by a "scribe," consisting of a bar of wood, with metal teeth placed at equal intervals.

The cutting into bars of the desired size may also be done by hand, by means of a strong wooden frame, or lever, with wires stretched across, which cut the slabs into bars as the lever is caused to descend. Slabbing and barring machines are generally employed in large factories. Fig. 2 shows one of the former, the cutting into slabs being also effected by wires. The machine shown in 3 serves for the cutting of the slabs into bars, which generally weigh about 3 lb. These, again, can be cut into tablet form by turning the handle on the left of the figure. The bars or tablets are then exposed to the air, or to a slightly heated atmosphere, to render them externally dry. The stamping with the particular brand of the soap, and with the name of the maker, is also done by hand or by machinery.



5. PLODDING OR SQUEEZING MACHINE
(A. Saalfeld & Co.)

Soft Soaps. As already indicated, soft soaps are generally manufactured from the liquid vegetable oils, such as cottonseed and linseed, and sometimes from the fatty acids derived from these, resin and fish oils are employed in the inferior qualities. The alkali used is potassium hydrate, in the form of a strong lye. The saponification is carried out by boiling the oil with the lye in an iron copper by means of "open" steam, the operation being generally completed by fire-heat or "close" steam. Care is required to see that the lye is not present in large excess, and that the finished soap contains the proper proportion of water. It is then run into barrels, kegs, or tins, for use by the consumer.

Soft soaps generally appear as transparent jellies; sometimes in cold weather they become partly opaque, due to the formation of small white crystals of alkaline stearate, this condition being known as "figging." When fatty oils are used, the glycerin resulting from the saponification remains with the

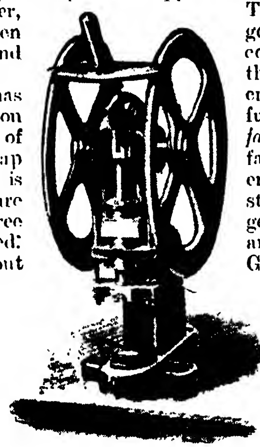
soap, as in the making of hard soaps by the cold process.

Soft soaps contain a much larger proportion of water than hard soaps, and generally contain also an excess of caustic alkali, as well as carbonate, and other impurities present in the materials used.

They are largely employed for general household purposes, such as the scrubbing of woodwork, etc., and by woollen manufacturers in the various operations of washing and "fulling" their goods.

Toilet and Fancy Soaps. The best qualities of toilet soaps are made by the boiling process, and lower qualities by the cold process. Many of the cheap toilet soaps are prepared by re-melting stock soaps of good quality, incorporating some perfume and colouring matter, and transferring to cooling-frames, when the soap is afterwards cut up and stamped into tablets.

A very important improvement has taken place of late in the preparation of toilet soaps, by the introduction of the milling process. A well-made soap obtained by the boiling process is generally selected for the purpose, care being taken that all traces of free alkali have been completely neutralised. A soap of this kind contains about 30 per cent. of water, and, as a preliminary to the milling process, the soap requires to be deprived of the bulk of the water by drying. This may be done by cutting the bars of soap into shreds and exposing these in a steam-heated chamber. In large and modern establishments the drying is carried out continuously in a special form of apparatus introduced by M.M. Cressonnières, of Brussels (English Patent No. 2,446, 1890). For this purpose the molten soap is first passed between a series of iron rollers, whereby it is cooled to some extent.



STAMPING MACHINE
(W. J. Fraser & Co).

customary to mix these materials with the dried ribbons of soap.

The *milling* or *crushing* machine [4] consists of a number of powerful granite rollers; between these the dried soap is made to pass several times in order to incorporate the colouring matter and perfume, and make the soap thoroughly homogeneous. The ribbons of soap, as they leave the milling machine, are afterwards subjected to great pressure in what is called a *plodding* or *squeezing* machine [5], in which, by means of a powerful screw or worm forcing the mass through an orifice of the desired size, the soap is formed into a compact bar, which is then cut, and stamped into tablets in moulds [6], the name of the soap, etc., appearing in well-defined letters on the surface.

The most important qualification of a good toilet soap is freedom from uncombined alkali and other irritants of the skin. It should also yield a rich, creamy lather, and be delicately perfumed. In the preparation of *super-fatted* soaps, a small quantity of neutral fatty matter was at one time added, to ensure absence of free alkali, but such substances as lanolin and spermaceti are now generally preferred, in order to produce an emollient effect upon the skin. Glycerin is also frequently added.

The best *transparent* soaps are prepared by dissolving a good soap in spirit, distilling off the excess of the latter, and allowing the remaining soap solution to solidify. The soap is then cut into tablets, and these exposed to the air for several weeks or months. Inferior qualities contain a considerable proportion of sugar.

Composition of Soaps. The following table gives the composition of representative soaps of the various qualities which have been referred to; they are all of English manufacture.

--	Curd (genuine)	Mottled (genuine)	Mottled (silicated)	Yellow (genuine)	Yellow (silicated)	Yellow, "washer" variety (genuine)	Coconut (made by "cold" process)	Soft (potash)	Toilet, "milled" (superior quality)	Toilet, transparent (sup. qual.), made by spirit proc.	Toilet, transparent (inferior quality)
Fatty anhydride ..	62·02	64·20	40·44	61·12	41·18	63·80	50·02	40·22	80·08	80·64	40·87
Alkali, Na_2O	7·82	7·79	6·78	7·00	6·39	8·00	7·88	--	10·12	8·97	5·95
,, K_2O		-	—	—	--	-		9·23		—	—
Silica, SiO_2		--	1·38	-	2·01		—	—		—	—
Salts (including little glycerin)	2·46	2·61	4·60	2·64	3·26	2·62	—	·	1·49	2·15	—
Glycerin (including small quantity salts)	—	—	—	—	--	·	9·70	7·43	—	—	—
Sugar (including small quantity salts)	---	---	—	—	---	--	--	·	—	—	28·23
Water	27·70	25·40	46·80	29·21	47·16	25·58	32·40	43·12	8·31	8·24	24·95
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00
Fatty acids, Titre °C. ..	39·7	38·9	37·2	42·0	42·0	28·3	23·6	31·1	38·9	41·7	31·1
.. ,, Sapon. value	214	203	210	196	195	216	267	198	212	—	---

By means of a row of iron teeth impinging upon the bottom roller, the soap is removed in the form of thin shreds or ribbons, and in this condition it falls upon an endless band of fine wire gauze, and is carried through a heated, well-ventilated chamber, where it is rendered comparatively dry, about 10 to 12 per cent. of water remaining in the product. The colouring matter, which is generally an aniline derivative, and the perfume may be added before drying, but it is

Soap or Washing Powders. These consist of mechanical mixtures of soda crystals (Na_2CO_3, $10H_2O$), or soda-ash (Na_2CO_3), and dry soap, and are prepared by grinding the materials together until the mass is reduced to a state of fine powder.

They are powerful, although not economical, detergents, and are useful for the cleansing of kitchen utensils and other greasy articles.

The following table gives the percentage composition of three well-known brands: 1 and

2 are of English, and 3 is of American, manufacture:

—	1	2	3
Fatty anhydride	18·16	18·76	22·83
Alkali, Na_2O, combined as soap	2·08	2·20	2·43
Sodium carbonate, Na_2CO_3	32·22	37·05	50·18
Water	44·68	38·35	21·96
Salts	2·86	3·64	2·60
	100·00	100·00	100·00

GLYCERIN

By John McArthur

Glycerin, or glycerol, $C_3H_5(OH)_3$, was first isolated by the Swedish chemist Scheele, in 1779, in the preparation of lead plaster from olive oil and litharge, and named by him the "sweet principle of oils."

It is now obtained as a by-product in the hydrolysis or saponification of oils and fats in the stearine candle and soap industries, a fat, like tallow, yielding about 10 per cent. of glycerol. Within comparatively recent years much of the resulting glycerin was run to waste, but the improvement in the methods for its recovery and purification, and at the same time its extensive application in various industries, have enabled manufacturers to convert this formerly waste product into one of value and profit. The crude glycerin of commerce varies in quality with the particular process of saponification employed; the principal qualities are *saponification* or *candle-glycerin* and *soap-lye glycerin*.

Saponification Glycerin. This is obtained in the making of stearine, discussed under Candles. The glycerin-water, or "sweet-water," obtained by the hydrolysis of the fat, is concentrated by means of steam, preferably in a vacuum evaporator, until a specific gravity of about 1·240 is reached, corresponding to about 90 per cent. of glycerol. This product varies in colour from light yellow to dark brown or black, according to the quality of the raw fats employed, and contains generally from 0·25 to 1·00 per cent. or more of salts, consisting of lime, magnesia, etc., from the base used in the hydrolysis, besides dissolved organic impurities.

Soap-lye Glycerin. The spent lyes resulting from the "cutting" of the soap generally contain from 4 to 8 per cent. of glycerol; common salt is also present in considerable quantity, besides smaller proportions of caustic soda, carbonate of soda, and soap. The lyes are purified by treatment with mineral acid, in presence of certain chemicals such as sulphate of alumina or ferric sulphate: by this combined treatment the alkali is neutralised, the soap decomposed, and the fatty and resinous acids as well as organic impurities precipitated. The solution is filtered, neutralised with soda-ash, again filtered, and concentrated in a vacuum evaporator, which is constructed so that the excess of salt, as it separates from the lye, can be removed from the evaporator while the process is in operation. The finished crude glycerin has a specific gravity of 1·300, and contains generally about 80 per cent. of glycerol and 10 per cent. of salt.

This quality, on account of the higher percentage of salt and the lower percentage of glycerol present, has not the same commercial value as saponification glycerin.

Purification of Glycerin. The first successful process for the purification of crude glycerin was that invented in 1855, by the late Mr. G. F. Wilson, F.R.S., of Price's Patent Candle Company Limited (English Patent No. 301, 1855), whereby the well-known "Price's Glycerin" was manufactured. This process consists in distilling the glycerin in an atmosphere of superheated steam, and although its original form has now been somewhat modified, the process is universally used.

The stills and condensers employed vary in form, but are somewhat similar to those used for fatty acids [see Candles]. They are made of copper or steel, and the glycerin is distilled, in some cases by superheated steam with the assistance of fire, and in other cases by steam alone. The whole apparatus is generally worked under a vacuum, which, by reducing the temperature of distillation, assists in preventing the decomposition of the glycerin. Strong glycerin of 1·240 to 1·260 specific gravity is collected from those condensers near to the still; the weaker glycerin from the other condensers is generally concentrated in vacuo and re-distilled. The strong glycerin, which is pale yellow in colour, is decolorised by treatment with animal charcoal and filtered, and is sold as *distilled glycerin*, or it may be concentrated to a specific gravity of 1·262 for *dynamite glycerin*.

Chemically pure glycerin is obtained by a second, and sometimes by a third, distillation, and is generally finished by treatment with a small quantity of pure charcoal, and afterwards filtered.

Properties of Chemically Pure Glycerin. Chemically pure glycerin, as required by the British Pharmacopœia has a specific gravity of 1·260 at 15·5° C.; it is not absolutely free from water, containing between 2 and 3 per cent., the chemical substance, glycerol, having a specific gravity of about 1·267 at 15·5° C. Chemically pure glycerin is a colourless syrupy liquid, free from odour, and possessing a sweet, pleasant taste. It should be free from arsenic, metallic and earthy impurities, and from fatty and mineral acids. When exposed to cold for some time, at or below 0° C., it forms rhombic crystals, which rapidly deliquesce on exposure to the atmosphere. It boils at 290° C., and at a higher temperature burns with a non-luminous flame. Glycerin has a great affinity for water, and mixes with it and with alcohol in all proportions, but it is insoluble in ether. It is a very powerful solvent, dissolving many substances which are practically insoluble in water.

Applications of Glycerin. Chemically pure glycerin is extensively employed in pharmacy and surgery. Its solvent action renders it useful in making solutions of various drugs. On account of its nutritive value, it is often taken internally as a substitute for cod-liver oil. It is largely used as an application in diseases of the skin, being employed as a vehicle for medicaments; and in combination with such antiseptics as boric and salicylic acids, it is useful as an application in certain diseases of the throat. Glycerin is useful also as a preservative fluid, and on this account it forms an important constituent of vaccine lymph.

Distilled glycerin is used in calico-printing, in the preparation of leather, and in the manufacture of copying inks and printers' rollers, and for mixing with water to lower its freezing-point. But by far the most extensive application of distilled glycerin is for the making of nitro-glycerin for dynamite and other explosives; for this purpose the glycerin should contain as little water as possible.

ESSENTIAL OILS AND PERFUMES

Essential or volatile oils are an important class of oils which differ from the division known as *fixed oils* by the fact that they are more or less vapourisable without alteration, and possess distinctive odours. This definition cannot be strictly applied in every case, but it suffices for all practical purposes. It is the possession of characteristic odours and the ready volatility that make essential oils of such value to perfumers.

Distribution in the Plant. Essential oils are of vegetable origin, and are distributed in all parts of the plant—flower, fruit, stem, bark and root; but this is not always so in the same plant. Pine trees are an example of the occurrence of the same oil in all parts of the plant, but in the rose the perfume or essential oil is found only in the flower petals. The orange tree is peculiar in yielding distinctive perfumes from various parts of the plant—the flowers yield oil of neroli, the leaves oil of petit grain, and the rind of the fruit, oil of orange peel. White flowers are more often perfume yielders, and give by far the most pleasant scents.

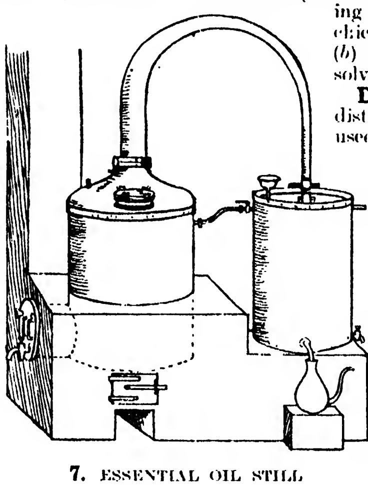
How Essential Oils are Formed. Charabot has conducted a series of experiments with a view to tracing the elaboration of perfumes in plants, using for the purpose peppermint and basil. There appears to be no doubt that the essential oil is produced in the chlorophyll-bearing parts of the plant. It was noted that the essential oil derived from the chlorophyll-bearing (green) parts is richer in esters, the more odorous part of essential oils, and becomes richer as vegetation advances. Suppression of inflorescence was found to cause an accumulation of the oil in the green parts. The flowers as formed become richer in water, the petals containing a higher proportion of water than the rest of the organs. During the fuller development of a flower the essential oil becomes richer in esters and in alcohols. In the case of the basil plant the essential oil is formed mostly in the green parts before the period of flowering, and decreases during the period of flowering.

Influence of Soil. Sunlight favours the formation of terpene compounds, and experiments are being conducted to see what effect the addition of certain chemicals to the soil will have on the composition of the oil. As an instance of the difference in the composition of the essential oil yielded by the same plant on different soil lavender may be mentioned. Plants grown at Mitcham, in Surrey, contain only about 7 to 10 per cent. of linalyl acetate, whereas the same plants grown in the South of France frequently contain over 35 per cent. of the same body. Peppermint plants cultivated in soil to which sodium chloride or sodium nitrate has been added yield an oil richer in ester than one cultivated without such addition.

Chemical Composition. The chemical constituents of volatile oils have been the subject of long investigations by chemists. The following are the chief organic constituents: (1) the terpenes, comprising pinene, camphene, limonene, dipentene, thujene, fenchene, sylvestrene, phellandrene, terpinolene, terpinene, cadinene, carvestrene, caryophyllene and cedrene; (2) camphor compounds such as borneol, camphor, terpineol, pulegiol and menthol; (3) the geraniol and citronellol series, including geraniol, linalol, geranaldehyde, and citronellol; (4) benzene compounds, the most important of which are cymene and its isomers, chavicol, eugenol, safrol, thymol, carvacrol, benzyl alcohol, benzaldehyde, salicylic aldehyde, cinnamic aldehyde, carvone, benzoic acid, salicylic acid and cinnamic acid; (5) aliphatic compounds, other than the geraniol and citronellol series, which comprise methyl alcohol, ethyl alcohol, propyl alcohol, acetic acid, valeric acid, hydrocyanic acid, allyl thiocyanate and the paraffins.

Many essential oils consist of a mixture of fluid and solid constituents, the fluid being known as the *elæoptene*, and the solid part as the *stearoptene*. *Terpeneless oils*, or concentrated essential oils, are obtained by depriving oils of their terpene, usually the odourless portion.

Processes of Extraction. The methods of obtaining the essential oil of plants varies according to the delicacy of the oil. The chief methods are: (*a*) distillation; (*b*) expression; (c) extraction by solvents.



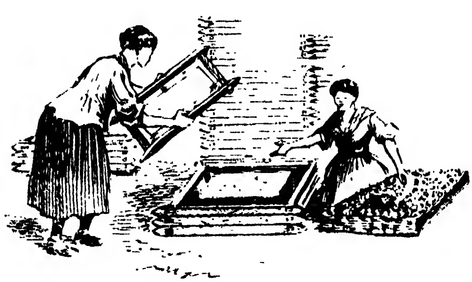
7. ESSENTIAL OIL STILL

Distillation. The process of distillation is the one most frequently used. The vegetable matter is placed in a copper still [7] with water, and heat is applied. This causes the water to rise as steam, containing, mixed with it, the essential oil of the plant. The steam is led through a worm or condenser, the resulting liquid being allowed to rest for some time, when it separates into two layers—oil and water. The oil is separated by a simple expedient of decantation. Modifications of the above process consist in the use of steam pipes as the heating agent and the suspension of the vegetable matter in a wire cage, the object being to prevent scorching. The water which comes away with the oil is strongly flavoured with the plant perfume, and is used in medicine for flavouring purposes, or, as in the case of rosewater, for toilet articles.

Making Otto of Rose. As an illustration of the distillation process the manufacture of otto of rose may be cited. The pure odour of the rose is "unique, undefinable and incomparable." *Otto*, or *attar*, is the name given to the oil of rose. The rose garden of the world is situated in the Balkans, the most important centre of the industry being Kezanlik. *Rosa Damascena* is the particular variety of rose cultivated in Bulgaria. The flowers grown for the distillation of the otto are gathered before they begin to open and just before sunrise. The time of gathering has an important influence on the otto, both in yield and odour. A garden of an acre yields about 100 lb. of flowers every day for three weeks. The distilleries are, as a rule, primitive buildings. The still [8] is of copper, about 5 ft. high, resting on a furnace built of bricks or stones. The condenser is simply a straight tube passing obliquely through a wooden vat. The fuel for heating the furnace consists of

wood. Water for condensation is supplied by a wooden gutter suspended over the condenser. The still is charged with 10 kilogrammes of flowers just as they are gathered and 75 litres of water, and the joints of the still are luted with clay. The fire is then lighted, and after an hour and a half 10 litres of liquid, having distilled over the fire, is withdrawn. The distillate is received in two flasks of 5 litres each and placed on a shelf to cool. The still is then recharged, and when 40 litres of distillate have been collected, this quantity is put in the still and 5 litres of distillate collected, containing all the otto of the larger quantity. The liquid is placed in a glass vessel of special shape, and the otto that floats on the water is separated by a small funnel-shaped dipper. The yield from 3,000 kilogrammes of flowers is 1 kilogramme of otto. Modern methods of distillation are now used in the newer factories.

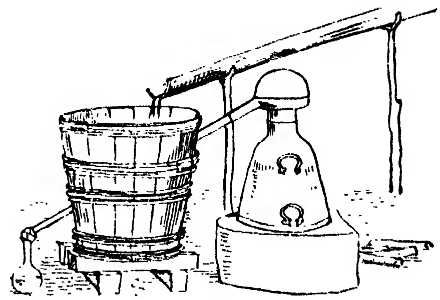
Expression. This is the process used in Southern Italy for obtaining essential oil from lemon, orange, and bergamot peels, but in reality very little pressure is employed. The principle on which the extraction is carried out may be illustrated by bending a piece of orange peel, when a fine shower of oil and water will be seen to be ejected. In peeling a lemon or orange, a little of the oil is in this way often ejected into the eye, causing considerable pain. If a piece of sponge be pressed on the bended peel, the oil is absorbed, this being the method which goes by the name of the *spugna* process. The peel of a lemon or orange is cut off in three slices by a workman, who passes them to an assistant sitting on a low chair, with a common quality bath sponge, worth about sixpence, in one hand. With the other, he presses the slice of peel against the sponge, pressing the edges of the peel only with the fingers, the object being to press the convex piece of peel as nearly flat as possible. The amount of pressure used is very slight. The sponge is periodically squeezed, a workman by this method producing 1½ lb. of oil of lemon per day. Another process is the *scorzetta* process. The fruits are cut into halves, the pulp removed by a kind of spoon, and all parts of the peel are then pressed against a sponge by constantly turning it in the palm of the hand. The *machina* process is a mechanical method applied principally to bergamot, as the round, regular shape of the fruit makes it very suitable for mechanical



9. ENFLEURAGE

treatment. A dozen bergamots of equal size are placed in a round copper receptacle provided with a heavy lid, which rests on the fruit; the interior of this receptacle is provided with fine, small teeth, and the whole revolves round an axis; the teeth rasp off the outer layer of the peel, which contains the oil, and this pulp is filled into long woollen bags, from which the oil drops on gentle pressure.

Extraction by Solvents. *Enfleurage* [9] is a process employed for extracting the perfume from flowers, and is applicable to those flowers like jasmin and tuberose, which contain only an insignificant amount of perfume, but continue to develop and emit perfume. A thousand kilogrammes of jasmin by distillation yield 178 grammes of essential oil, but by enfleurage 1,784 grammes



8. BULGARIAN OTTO OF ROSE STILL

are obtained. The process consists in spreading upon glass trays, framed with wood, about 3 in. deep, a layer of specially prepared fat, about ½ in. thick. The tray is then sprinkled with the flowers, which are renewed from day to day, the fat in time becoming saturated with the odour of the flowers. The perfume, or essential oil, is dissolved out from the fat by means of alcohol, forming an *extract*, but the perfumed fat is sold as a *pomade*. In some factories, warm, melted fat is employed for extracting the odour of flowers, the heat being maintained at a definite temperature. Volatile solvents are also employed instead of fat, examples of these being petroleum ether, chloroform, carbon bisulphide, and methyl chloride.

The table on next page gives the names of best-known essential oils, the sources, the parts yielding the oil, and the use of the oil being briefly indicated.

Various Aromatic Products. *Balsam of Gilead* and *Balsam of Mecca*, oleo-resins, considered to be derived from *Balsamodendron gileadense*, Kunth, or its varieties. When fresh, the oleo-resin is of the consistency of honey, of a greenish yellow colour, and with a powerful, pleasant odour, recalling that of rosemary. It is highly esteemed in the East as a cosmetic unguent.

Balsam of Peru is a fragrant balsam extracted from the trunk of *Myroxylon pereiræ*, Klotzsch, which grows in the western part of the State of San Salvador. It is a dark-brown, thick liquid, with a smoky, balsamic odour, which becomes very agreeable when warmed. It is used in ointments and in incense.

Balsam of Tolu, is obtained by exudation after incision in the bark of *Myroxylon toluifera*. It is a light-brown, soft resin, which becomes harder by age, but softens by the warmth of the hand. It is used in fumigating compounds, and largely in medicine as a cough remedy.

Benzoin is a gum obtained from *Styrax benzoin*. There are two chief kinds in commerce, Sumatra and Siam. Both are imported in blocks, the Siam being the better on account of its delicate odour, recalling that of vanilla. Both yield benzoic acid when heated. Benzoin is used in incense, in medicine, and as an ingredient in face lotions.

Camphor is derived from *Cinnamomum camphora*, Nees and Ebermaier, by boiling the wood of the

SOURCES AND USES OF THE CHIEF ESSENTIAL OILS

Name of Essential Oil.	Botanical Source.	Natural Order.	Part Yielding the Oil.	Use of the Oil.
Almond oil (bitter)	Prunus amygdalus, var. amara De C. ..	Rosaceæ	seed	flavour
Amber oil ..	Pinites succinifer, Goeppert (extinct) ..	Conifera	fossil resin	medicine
Ambrette seed oil (Musk seed)	Abelmoschus moschatus, Moench ..	Malvaceæ	seed	perfume
Anise oil	Pimpinella anisum, Linné	Umbelliferæ	fruit	medicine and flavour
Arnica root oil ..	Arnica montana, Linné	Compositæ	root	medicine
Basil oil	Ocymum basilicum, Linné	Labiatæ	herb	perfume
Beech tar oil ..	Fagus silvatica, Linné	Cupuliferæ	tar from wood	medicine
Bergamot oil ..	Citrus bergamia, Risso et Poiteau ..	Rutaceæ	rind of fruit	perfume
Birch tar oil ..	Betula alba, Linné	Cupuliferæ	tar from wood	perfume
Cade oil	Juniperus oxycedrus, Linné	Coniferæ	wood	medicine
Cajuput oil ..	Melaleuca leucadendron, Linné ..	Myrtaceæ	leaves	medicine
Camphor oil ..	Cinnamomum camphora (Linné), Nees et Ebermaier	Lauraceæ	camphor by-product	medicine
Caraway oil ..	Carum carvi, Linné	Umbelliferæ	fruit	medicine and flavour
Cardamom oil ..	Elattaria repens (Sonnérat), Baillon ..	Scitamineæ	seeds	flavour
Cassia oil	Cinnamomum cassia	Lauraceæ	wood	flavour and perfume
Cedar oil	Juniperus Virginiana, Linné	Coniferæ	wood	perfume
Celery oil ..	Apium graveolens, Linné	Umbelliferæ	fruit	flavour
Chamomile oil ..	Anthemis nobilis, Linné	Compositæ	flower heads	medicine
Cherry Laurel oil	Prunus lauro-cerasus, Linné	Rosaceæ	leaves	flavour
Cinnamon oil ..	Cinnamomum zeylanicum, Breyn ..	Lauraceæ	leaves and bark	medicine and flavour
Citronella oil ..	Cymbopogon nardus, Stapf.	Graminaceæ	grass	perfume
Clove oil	Eugenia aromatica (Linné), O. Kuntze	Myrtaceæ	flower heads	medicine and flavour
Copaiba oil ..	Copaiba Langsdorfii (Desfontaines), O. Kuntze	Leguminaceæ	oleo-resin	medicine
Coriander oil ..	Coriandrum sativum, Linné	Umbelliferæ	fruit	medicine and flavour
Cubeb oil ..	Piper cubeba, Linné filius	Piperaceæ	unripe fruit	medicine
Cumin oil ..	Cuminum cyminum, Linné	Umbelliferæ	fruit	medicine and flavour
Dill oil	Anethum graveolens, Linné	Umbelliferæ	fruit	medicine
Eucalyptus oil ..	Eucalyptus globulus, Labillardiere, E. Oleosa, F. von Mueller, and other species	Myrtaceæ	fresh leaves	medicine
Fennel oil ..	Fœniculum capillaceum, Gilibert ..	Umbelliferæ	fruit	medicine
Gaultheria oil (winter green)	Gaultheria procumbens, Linné ..	Ericaceæ	leaves	flowers
Geranium oil ..	Several species of pelargonium ..	Geraniaceæ	herb	perfume
Guaiacum oil ..	Guaiacum officinale, Linné, and G. sanctum, Linné	Zygophyllaceæ	wood	perfume
Hop oil	Humulus lupulus, Linné	Urticaceæ	strobiles	flavour
Horsemint oil ..	Monarda punctata, Linné	Labiatæ	herb	medicine
Hyssop oil ..	Hyssopus officinalis, Linné	Labiatæ	herb	medicine and flavour
Juniper oil ..	Juniperus communis, Linné	Coniferæ	fruit	medicine and flavour
Lavender oil ..	Lavandula officinalis, Chaix	Labiatæ	fresh flowers	medicine and perfume
Lemon oil ..	Citrus limonum, Risso	Rutaceæ	fresh peel	medicine and perfume
Lemon grass oil ..	Cymbopogon flexuosus, Stapf.	Graminaceæ	grass	perfume
Limes oil	Citrus limetta, Risso	Rutaceæ	rind of fruit	perfume
Mace oil	Myristica fragrans, Houttuyn	Myristicaceæ	arillode of seed	flavour
Marjoram oil ..	Origanum majorana, Linné	Labiatæ	herb	medicine and flavour
Mustard oil (volatile)	Brassica nigra (Linné), Koch	Cruciferæ	seeds	medicine
Myrcia oil (Bay oil)	Myrcia acris, D.C.	Myrtaceæ	leaves	perfume
Myrtle oil	Myrtus communis, Linné	Myrtaceæ	leaves	medicine
Nutmeg oil ..	Myristica fragrans, Houttuyn	Myristicaceæ	seeds	flavour
Olibanum oil ..	Species of Boswellia	Burseraceæ	gum resin	perfume
Opoponax oil ..	Opoponax chironium, Koch	Umbelliferæ	gum resin	perfume
Orange-flower oil (neroli oil)	Citrus vulgaris, Risso	Rutaceæ	fresh flowers	perfume
Orange peel oil ..	Citrus vulgaris, Risso, or C. Aurantium, Linné	Rutaceæ	fresh peel	flavour and perfume
Orris oil	Iris germanica, Linné, I. pallida, Lam., and I. florentina, Linné	Iridaceæ	rhizome	perfume
Parsley oil ..	Petroselinum sativum, Hoffmann ..	Umbelliferæ	fruit	medicine
Patchouli oil ..	Pogostemon patchouli, Pellet	Labiatæ	leaves	perfume
Pennyroyal oil ..	Mentha pulegium, Linné	Labiatæ	herb	medicine
Peppermint oil ..	Mentha piperita, Smith	Labiatæ	herb	medicine and flavour
Petit grain oil ..	Citrus bigaradia, Duhamel	Rutaceæ	leaves and fruit	perfume
Pimento oil ..	Pimenta officinalis, Lindley	Myrtaceæ	nearly ripe fruit	medicine
Pine oil	Pinus silvestris, Linné	Coniferæ	leaves	medicine
Rose oil (Otto of rose)	Rosa damascena, Mueller	Rosaceæ	fresh flowers	perfume and flavour
Rosemary oil ..	Rosmarinus officinalis, Linné	Labiatæ	leaves	perfume and medicine
Santal oil ..	Santalum album, Linné	Santalaceæ	wood	medicine and perfume
Sassafras oil ..	Sassafras variifolium (Salisbury), O. Kuntze	Lauraceæ	bark of root	perfume and flavour
Savine oil	Juniperus sabina, Linné	Coniferæ	tops	medicine
Spearmint oil ..	Mentha viridis, Linné	Labiatæ	fresh herb	medicine
Star anise oil ..	Illicium verum, Hooker filius	Magnoliaceæ	fruit	medicine and flavour
Tansy oil	Tanacetum vulgare, Linné	Compositæ	herb	medicine
Tar oil	Pinus palustris, Miller, and other species	Coniferæ	tar of wood	medicine
Thyme oil ..	Thymus vulgaris, Linné	Labiatæ	leaves and flowers	medicine
Turpentine oil ..	Pinus palustris, Miller, and other species	Coniferæ	oleo-resin	medicine and arts
Vetiver oil ..	Vetiveria zizanioides, Stapf.	Graminaceæ	root	perfume
Ylang-Ylang oil ..	Cananga odorata, Hooker filius et Thomson	Anonaceæ	flowers	perfume

tree in water, and leading the steam (which contains the camphor in the form of vapour) into inverted earthenware pots. It is re-sublimed in England by heating with quicklime and charcoal, the vapours being led into glass bell jars. Camphor is a white, tough, semi-crystalline solid mass, very soluble in alcohol, and slightly soluble in water. It finds numerous uses in perfumery and medicine.

Frankincense, or *Olibanum*, is used principally for compounding incense for use in churches. It is obtained from various species of *Boswellia*.

Myrrh is a reddish oleo-resin, obtained from *Balsamodendron myrrha*, Nees, much used in toilet perfumery.

Storax, or *Styrax*, is yielded by *Styrax officinalis*, Linn. It is an opaque, grey, semi-fluid resin, of the consistency of honey, exported from Arabia. It is used in incense.

Tonka, or *Tonquin bean*, is the seed of a leguminous tree, *Dipterix odorata*, Willd., which inhabits Guiana and Venezuela. It contains about 1·5 per cent. of an odorous principle, coumarin. Tonka bean is largely used to flavour tobacco, in sachet powder, and for flavouring purposes.

Vanilla is obtained from *Vanilla planifolia*, which is grown in Mexico, Réunion, the Seychelles, and Java. It is in the form of thin pods, 6 in. to 12 in. long. The aromatic principle, vanillin, occurs in quantities varying from 1 to 2·75 per cent. It is also made artificially. Vanilla is used as a flavour for chocolate and confectionery, and in the compounding of numerous liqueurs and perfumes.

Perfumes of Animal Origin. *Musk* is obtained from the musk deer, *Moschus moschiferus*, Linn., in bags or pods, containing an average quantity of half an ounce. The pods are often adulterated, the high price being a great incentive to sophistication. It is a most persistent perfume, and, like other animal perfumes, is much employed as a fixing agent in perfumery. A tincture in weak alcohol, sometimes with the addition of a little ammonia, or fixed alkali, is the form in which musk is employed. Artificial musk is referred to in next column.

Various animals give out an odour of musk. These are *Ondrata zibethica* (the Canadian musk rat), *Mygale moscovita* (Russian musk rat), *Sorex indicus* (Indian musk rat), *Bos moschatus* (musk ox), and *Antelope dorcas*, but they are very little employed in perfumery.

Civet is a secretion of the civet cat, *Viverra ivetta* and *V. zibetha*. The odour is more powerful than musk, but its diffusiveness is not so great. On being much diluted, the odour of civet becomes bearable, and even fragrant.

Ambergris, the biliary concretion of the spermaceti whale (*Physeter macrocephalus*), is a product of disease. It has an odour recalling musk, but is more delicate. Its use is for giving permanence to other odours, and a handkerchief scented with ambergris retains the odour even after being washed. It is a rare product, but is occasionally found in large pieces by lucky whale fishers. Ambergris costs about £5 to £10 an ounce, but is often grossly adulterated.

Synthetic Perfumes. The modern industry of manufacturing perfume from coal-tar is but a small part of the great triumphs which chemistry can claim to have achieved. Some of the most exquisite odours in modern perfumes are manufactured entirely from aniline products, and although some perfumers allege that the natural floral odours have a bouquet which art cannot match, it is safe to say that the popularisation of perfumery has in a great measure been brought about by the originality of synthetic perfumes. Oil of almonds may be said to be the first synthetic odour. Mitscherlich, in 1834, discovering the exact counterpart in *nitrobenzol*—a coal-tar product. Nitrobenzol is known as *oil of mirbane*, and although the odour is the same as bitter almonds, its poisonous properties prevent it being used as a flavour. *Benzaldehyde* is another artificial oil of almonds which is soluble in alcohol. These artificial products are employed in perfuming soap. Artificial *vanillin*, which reproduces the odour of vanilla, was first made by Tiemann, in 1874, from coniferin, but now the most important method of preparing vanillin is by the oxidation of eugenol, the chief constituent of oil of cloves. The eugenol is first converted into isoeugenol by treating it with caustic potash. The acetylation product is oxidised, by which acetylvanillin is chiefly formed, and this yields vanillin by splitting off the acetyl group. Vanillin is in fine white needles, possessing an intense odour of vanilla, and dissolves in alcohol, water, and glycerin. *Coumarin* is the peculiar odour of Tonka bean, which is employed in making "New-Mown Hay" perfume. It is now made artificially by the action of caustic soda on phenol, a sodium salt of salicylaldehyde being formed; this is acetylated, and the acetyl compound, heated to a high temperature, splits up into coumarin and water. Coumarin dissolves in alcohol and oil, a little oil being usually associated with it for fixing purposes. *Heliotropine*, or piperonal, is an artificial product with a delightful odour of heliotrope. It was originally made from piperine, the active principle of pepper, but is now made from safrol, the principal constituent of oil of sassafras. It is used to make "White Heliotrope" perfume. *Aubépine*, or anisic aldehyde, is the substance used to give "May blossom" or "Hawthorn" perfume. It is obtained as a by-product in making coumarin, or can be made from aniseed oil. *Cinnamic aldehyde* is artificial cinnamon made by the action of caustic soda on benzaldehyde and acetic aldehyde. *Terpineol* is a liquid exactly reproducing the odour of "White Lilac." It is made by the action of dilute sulphuric acid on terpene hydrate. *Ionone*, or artificial violet, is the basis of the popular "Parma Violets" perfume. It was first made by Tiemann, in 1893, by submitting a mixture of citral (obtained from lemongrass oil) and acetone to the action of hydrates of the alkaline earths in the presence of water, and then converting the ketone-pseudo-ionone into ionone by the action of dilute acids. It is sold commercially as a 10 per cent. solution, which is diluted to make violet perfume. *Artificial musk* was first made in 1842 by the action of nitric acid on oil of amber, but the artificial musk of to-day is made by the Baur expired patent, and is a tri-nitro derivative of butyl toluol. It is a white crystalline powder, soluble in organic solvents. *Artificial neroli* is the methyl ester of anthranilic acid, but other compounds are also sold in imitation of orange flowers. Other artificial perfumes are *amyl salicylate* (resembling orchid and trefoil), *benzyl acetate* (like jasmin and ylang-ylang), *geraniol* (rose odour), *rhodinol* (synthetic rose), and *vetivol* (like oil of vetiver). Many artificial ethers have the odour of fruits, and are employed in compounding fruit essences for flavouring purposes and aerated waters.

Analysis of Essential Oils. The chief points in the examination of essential oils for the detection of adulterants are the determination of its specific gravity, refractive index, rotation, melting and solidifying points, and boiling point.

The specific gravity is taken in a graduated specific gravity bottle of a capacity of 25 cc. or 50 cc. The bottle must be carefully checked, and allowance made for any deviation from accuracy. The temperature of 60° F. or 15·5° C. is that most conveniently employed in this operation. The specific gravity of very small quantities of oil is determined in small Sprengel tubes. The refractive index of an essential oil is determined in an ordinary spectroscope. The figure for the refractive index of essential oils is always high, but on account of the small limits within which oils differ its determination is not of great practical value. The rotation of an essential oil is, however, of much use in establishing identity and detecting adulteration. The polariscope is used for determining the rotation of an oil, the instrument being described in the article on Sugar Analysis. The melting and solidifying points are determined by means of an accurate thermometer heat or a freezing mixture being employed according to the object of the test. The boiling point is determined by means of a thermometer, while, if the examination is directed to discovering the constituent fractions of an oil, special fractionating flasks are employed.

Detecting Adulterations. Fixed oils are detected by placing a few drops on a piece of absorbent paper. Essential oils evaporate and leave no residue, while a fixed oil leaves a greasy spot on the paper. Alcohol is detected by shaking the essential oil with ten times its volume of water in a graduated tube. If the oil is appreciably reduced in volume, the presence of a considerable quantity of alcohol may usually be inferred. Turpentine may be often detected by the polariscope.

Perfume Recipes. The following are given as characteristic recipes for compound perfumes. They show the method of preparing these products, and give an idea of how the various odours are blended. The alcohol used is that known as rectified grain spirit, or deodorised alcohol, as it is important that the basis shall be quite free from any odour that would modify the resulting perfume.

Lavender Water. Oil of English lavender, 8 oz.; rosewater, 1 pint; alcohol, 8 pints. Distil till 8 pints of product is obtained.

Eau-de-Cologne. Oil of neroli, 3½ oz.; oil of rosemary, 1½ oz.; oil of orange peel, 8 oz.; oil of bergamot, 1½ oz.; alcohol, 5 gallons.

Hungary Water. Oil of rosemary, 10 dr.; oil of lemon, 3½ dr.; alcohol, 1½ pints.

Honey Water. Oil of bergamot, 7½ dr.; oil of lemon, 5 dr.; oil of lavender, 4 dr.; oil of cloves, 4 dr.; tincture of orris (1 in 4), 1 pint; orange-flower water, 1 pint; alcohol, 2 pints.

Ess Bouquet. Otto of rose, 4 drops; oil of neroli, 2 drops; essence of musk (2 dr. in 15 oz. alcohol), 40 drops; jasmin extract, 5 oz.; tincture of orris, 8 oz.; alcohol, 4 pints.

Jockey Club. Jasmin extract, 8 oz.; rose extract, 2 oz.; essence of musk, 2 oz.; tincture of Tonka bean (1 in 4), 4 oz.; alcohol, 1 pint.

White Lilac. Terpineol, 10 dr.; alcohol, 1 pint.

Opoponax. Musk, 1 oz.; vanilla, 8 oz.; Tonka beans, 4 oz.; alcohol, 10 pints. Macerate a month, and add tincture of orris, 4 pints; millefleur extract, 8 oz.; oil of orange peel, 2 oz.; oil of bergamot, 2 oz.; otto of rose, 1½ oz.; oil of opoponax, ½ oz.

White Rose. Oil of geranium, 40 drops; otto of rose, 100 drops; jasmin extract, 4 oz.; tincture of orris, 4 oz.; water, 4 oz.; alcohol, 1 pint.

Parma Violet. Ionone, 3 dr.; tincture of orris, 10 oz.; chlorophyll, to colour; alcohol, 30 oz.

Ylang-Ylang. Oil of neroli, 6 drops; oil of lemon, 6 drops; otto of rose, 15 drops; oil of ylang-ylang, 50 drops; essence of musk, ½ dr.; alcohol, 2 pints.

Florida Water. Oil of lavender, ½ oz.; oil of lemon, ½ oz.; oil of bergamot, ½ oz.; oil of neroli, 2 dr.; oil of melissa, 1 dr.; otto of rose, 20 drops; alcohol, 3 pints.

Bay Rum. Oil of bay, 1 dr.; oil of orange-peel, 1 dr.; oil of pimento, 1 dr.; water, 4 pints; alcohol, 8 pints.

Millefleur Sachet. Powdered orris root, 16 oz.; musk, 5 gr.; civet, 10 gr.; otto of rose, 20 drops; oil of neroli, 20 drops; oil of cloves, ½ dr.; oil of bergamot, 1 dr.

Pot-Pourri. Orris root, 1 oz.; vanilla, 1 oz.; cinnamon bark, 1 oz.; cloves, 1 oz.; oil of lavender, 10 drops, oil of neroli, 10 drops.

Incense. Olibanum, 20 oz.; benzoin, 6 oz.; storax, ½ oz.

Books on Essential Oils. Books on the subject of essential oils, which may be recommended, are as follow:

"Chemistry of Essential Oils and Artificial Perfumes," by E. J. Parry, 1899. (Scott, Greenwood & Co., London.)

"Notes on Essential Oils," by T. H. W. Idris, M.P., 1900. (Idris & Co., London.)

"Die Ätherischen Oele," by E. Gildemeister and F. Hoffman, 1899. (Springer, Berlin.)

An English translation is published in the United States.

"Die Ätherischen Oele," by F. W. Semmler, 1906. Two volumes are now published. (Von Vert & Co., Leipzig.)

"Les Huiles Essentielles," by E. Charabot, J. Dupont, and L. Pillet, 1899. (Béranger, Paris.)

Books on Perfumes. Treatises on perfumes include the following:

"Perfumes and their Preparations," by G. W. Askinson, 1892. (Spon, London.)

"Les Parfums Artificiels," by E. Charabot, 1900. (Baillière, Paris.)

"Art of Perfumery," by C. H. Piesse, 1891 (Piesse & Lubin, London.)

"Book of Perfumes," by Eugene Rimmel, 1868. (Chapman & Hall, London.)

"Treatise on Perfumery," by R. S. Cristiani, 1877. (Sampson Low, Marston, London.)

"Odorographia: Natural History of Raw Materials and Drugs used in the Perfume Industry." Two volumes, 1894. (Gurney, London.)

"Essays on Certain Processes and Products of Perfumery," by M. A. Theulier and M. J. Rodie, 1905. (Lautier, Grasse.)

"Die Synthetischen und Isolirten Aromatica," by J. M. Klimont, 1899. (Baldamus, Leipzig.)

Continued

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WHAT ARE WOMAN'S RIGHTS?

A Woman's Education. The Woman's Movement at Home and Abroad. The Rights of a Woman are to be a Woman, not to be a Man

By Dr. C. W. SALEEBY

The Womanliness of Woman. It has been maintained by some that any education of woman is undesirable, since it tends to make her discontented with her proper position and duties. At the other extreme is the notion that woman ought to be subjected to an educational discipline similar in kind and in amount and in rigour to that which is now undergone by men. We have seen that the consequence of this is simply defeminisation. What, then, are we to regard as the true rights of woman in this respect ?

It will surely be evident to the reader that any laying down law as to details would be monstrously absurd, for individual women vary at least as much as individual men. But we *can* lay down certain principles. The first unquestionably is that *any form of education which tends to produce a woman who is no woman is vicious and false.* It is no less vicious and false than would be a mode of education which produced men who were no men. Provided, however, that this fatal mistake is not made, as it *has* lately been made in America, we cannot for one moment deny the right of women to a liberal education, including even what is called higher education. Its dangers must be recognised from the first. It must be adapted to the peculiar needs and peculiar psychical tendencies of the female sex. Neglect of these precautions has led in America to the most disastrous results, which have lately undergone critical statistical examination. The subsequent history of thousands of college-trained girls has been examined. It is found that the marriage rate among them is abnormally low ; that those who do marry are relatively incapable of bearing children, and that of the few who bear children only very few are able to nurse them. To state these facts is, of course, to condemn such education outright. On the other hand, there are numerous instances which fortunately prove that when the higher education of woman is undertaken with due precautions, it is perfectly compatible with the retention of womanliness.

Each Sex is Necessary to the Other. Dr. Clouston has pointed out that "it is the most nervous, excitable, and highly-strung girls who throw themselves into the school and college competition most keenly, and they, of course, are just those most liable to be injured by it. Girls take a personal animus more than lads, and do not take a beating so quietly. The whole thing takes greater hold on them, and is more real. . . . Young women at adolescence are apt to have in large degree the feminine power of taking it out of themselves more than they are able to bear for long. Womanhood is apt, after such education, to be entered with a handicap. Nature has not got the material nor the force to build up the form towards the fair woman's ideal, and therefore personal beauty and grace of movement have not been attained to the extent that might have been. A store of latent energy, sufficient for future use, should have been laid up all this time for woman's special work, for motherhood, and for the race of the future. . . . Once fully formed as a woman, she can then stand much. She is capable of taking up any rôle that falls to her, whether it be teacher, daughter, or mother. *Whether she is an actual mother or not, she is infinitely the better for having the full capacity of motherhood.*"

These facts have to be recognised by the practical sociology of the future in its attempt to find out the true spheres and work of each sex, and to regulate our social system in accordance with that knowledge. We must entirely abandon and repudiate the notion that there should be any rivalry between the two sexes—"one of the most preposterous and unscientific feelings that has ever been expressed. Each sex has a place and a work which the other cannot do. Each is necessary to the other ; each completes the happiness of the other."

The Value of Education to a Woman. Having insisted upon our principles, let us consider the personal and sociological value of the rational education of woman, with the understanding that at the end of the process she is to remain a woman, and not to be a sexless creature for whom no name exists in our vocabulary.

In the first place, we must recognise the great personal value to the woman herself of larger interests and knowledge. This adds to the value of her life, and tends to relieve her from the opprobrium of being petty-minded and a gossip. Men have always blamed women for this tendency, but if men limited their own education, as they have limited woman's education in the past, they also would become petty-minded gossips. What do uneducated men talk about ?

Secondly, we must observe that the *adequate* education of woman is of the utmost value in relation to marriage and the family. If the education be *more than* adequate, marriage, the family, and the race suffer. Mental characters tend to be transmitted in the same proportion as bodily characters. This has been proved by Mr. Francis Galton and Professor Karl Pearson. It follows that the mental evolution of the race, which is the only kind of evolution that matters, will unquestionably be hastened by the choice of the more intellectual rather than the less intellectual women as the mothers of the future. This proposition offers a fatal objection to the over-education of women. The

disastrous course has been followed in America, and is now being followed by us, of choosing the most intelligent girls and then submitting them to a discipline which makes them incapable of motherhood. Obviously, no more fatal proceeding could be imagined. Other things being equal, every society wants the most intellectual women to be the mothers of its sons and daughters, so that their mental powers may be transmitted to future generations. A form of education which takes the women most valuable for motherhood, and then makes them incapable of it, stands self-condemned.

Over-education and Under-education. An equally important consideration for those who think closely enough depends upon the changes which over-education produces in woman's physique. Our quotation from Dr. Clouston shows that her "personal beauty and grace of movement" are interfered with. She therefore becomes less attractive to men, who for ages to come will certainly continue to choose their partners largely on physical grounds. Thus, over-education not only tends to make a woman incapable of maternity, but, as experience has shown, very seriously reduces her chances of obtaining the opportunity for maternity.

Let us now, on the other hand, observe the consequences of under-education in relation to marriage and the family. The first unquestionable fact is that, as men become more and more educated, they become less and less content with physical attractions, and those alone, in their partners. They want intellectual as well as physical companionship. The smallest acquaintance with the social life of ancient Greece will remind us of the danger to monogamy which is involved in the marriage of wholly uneducated dolls, while the company of brilliant and highly-educated women is to be found outside the marriage bond. The adequate education of women is therefore earnestly to be desired in the interest of marriage. It is also earnestly to be desired in the interests of the children of such marriages. If biography proves anything whatever, it is that a promising boy can have no better advantage than the possession of a loving and educated mother. Such mothers have again and again well and truly laid the foundations of the education which has afterwards brought their sons to eminence.

An Educated Woman's Value to Society. Finally, let us endeavour to appreciate the value for society at large of the adequate education of women. Very numerous instances may be cited, but we cannot do better than accord the first place to the case of medical women. As most people know, the endeavour of women to obtain medical education was strenuously fought in the seventies of last century. There still lives the distinguished lady, Mrs. Garrett Anderson, who, in 1865, obtained the first medical qualifications gained by a woman. The medical education of women is capable of serious abuse in accordance with what we have already said. Not a few women injure themselves by their keenness and some are defeminised, though the woman's blood in most of them will not be conquered. But it is now certain not only that women are capable of the necessary education—capable both intellectually and physically, and most conspicuously capable morally—but also that such women may be of the utmost value to society at large. There are very many kinds of medical work for which a woman is pre-eminently suited, nor are we thinking merely of the work which approximates to nursing.

Women and Vital Problems. The Council of the London School of Medicine for Women has lately stated that "as time goes on the peculiar fitness of highly-trained medical women for public service will become more and more apparent." We may take it as certain that the medical inspection and supervision of school-children will shortly be established in this country. The necessity for it and its value have long been beyond dispute. Now it has already been shown that for this kind of work, which is of such importance to the community, medical women possess a very special capacity and fitness. Again, there is the great problem of infant mortality—one of the greatest national problems to be faced by an empire with a home and colonial birth-rate continuously and rapidly falling. Meanwhile our infant mortality is as high now as it was sixty years ago, and it is practically all preventable. It has been proved by the energy and philanthropy of Mr. Benjamin Broadbent, the Mayor of Huddersfield, that, at the first attempt, the infantile mortality can be halved by the employment of medical women "whose duties are to give the mothers advice as to the nursing and rearing of their children, to encourage them in every way to follow Nature's method of bringing up their own children, and to inquire into infantile deaths in their districts." The National Conference on Infantile Mortality, held in London in 1906, passed the following resolution: "That, in the opinion of this Conference, the appointment of qualified women, specially trained in the hygiene of infancy, is necessary as an adjunct to public health work."

A Necessity for Civilisation. Those who watch the signs of the times are convinced that in a very few years such women will be employed in every city, town, and hamlet in the land, doing the work of keeping babies alive—which women have been doing, and women alone, ever since babies were invented. Experience proves that no man, however tactful and skilful, can possibly meet with similar success in work of this kind. A woman will listen to a woman on such matters, when she will not merely ignore a man but will deeply resent his interference. In addition to this public work, it is quite certain that, even in private practice, there are very many cases, such as child-birth and the diseases of children, for which women are very specially fitted. The higher education of women for this profession, when conducted with reason, and when the subjects are well-chosen, has conclusively proved itself to be of the very greatest value to society, and this value will become more apparent as time goes on.

It must be freely admitted that it is only parodying Nature, and not really obeying her,

for a woman to look after another woman's children instead of her own, and the higher education of women for the purpose of following any profession, even including that of medicine, will always be open to such a criticism. Nevertheless, as we have seen, the higher education of women, at any rate to an extent corresponding to an ordinary University course in Arts, is abundantly justified, and indeed may be regarded as necessary for the continuance of our civilisation.

Services Lost to the State. Now, we have to remember that the average expectation of life of women has markedly increased during the last few decades—being now, indeed, higher than that of men. Hence there are now great numbers of women, active physically and mentally, who have passed the child-bearing period, and for whom society, as at present constituted, makes little provision—its failure to do so injuring itself also. Our civilisation is producing many women who cannot content themselves with the ordinary vegetative processes of eating and sleeping and sitting in the sun, such as satisfied their ancestors. The woman who has led a busy life in the control and direction of her home and children finds herself destined to pass her declining years in the home of a married child, perhaps, where she has no duties of any kind to perform. The best thing that can happen to her is that she shall soon have grand-children to think about and help to care for. There is a very definite and very much to be pitied class of the community for whom, only quite lately, and only among the most advanced nations, is any adequate mental occupation provided—the elderly women, whose children have taken wing, but whose activities, especially their mental activities, are potentially unabated, but have nothing to act upon. They have experience, patience, insight, and their invaluable feminity; but society does not yet choose to avail itself of them. As the years advance such women run a great risk of becoming self-centred, losing their sense of proportion, and, since they have nothing worth while to concern themselves with, worrying about things that are not worth while.

The Injustice of Oxford and Cambridge. A more sensible society would recognise and utilise the social worth of such women. In this connection it is pitiable to note that recent legislation (1899) has temporarily cut such women off from certain forms of municipal service. Such a retrograde step, however, cannot long be accepted. Women of this class, who, as we have said, are becoming increasingly numerous, furnish a most valuable complement to men in various forms of administration, just as the mother furnishes a valuable complement to the father in the administration of a family.

In this country women still labour under very serious disabilities imposed by men. After a very long fight they have at last obtained for themselves the right of higher education. They can obtain degrees in arts and medicine from all the universities in this country except Oxford and Cambridge. Our two oldest universities, though they will permit a woman to avail herself of their educational opportunities, will not accord her any recognition of her work other than the receipts for her gratefully accepted fees. This disgraceful fact applies not merely to degrees in medicine, but even to degrees in arts. Thus we recently had the extraordinary spectacle of a woman being placed above the Senior Wrangler in the Mathematical Tripos at Cambridge, and yet being compelled to leave the University without the degree which was readily conferred upon men to whom she could give a start of ninety marks in a hundred and a beating. No respectable argument has yet been advanced in favour of this quite monstrous distinction. It is amusing to observe, however, that the authorities of Trinity College, Dublin, now confer arts degrees upon women who have qualified for them at Oxford or Cambridge. As finance is thus introduced into the question, there is some hope that the argument thence derived may move the authorities in whom the sense of justice and the sense of humour seem at present to be so deficient.

The Legal Injustice to Women. But the university disabilities of women affect only the very few, and, after all, do not affect them in any vital manner. We must now consider a number of much graver disabilities under which women still labour on account of their sex and that alone. The number of these has certainly been greatly reduced since attention was so conspicuously drawn to them by the famous little book, "The Subjection of Women," published by the great sociologist, John Stuart Mill, in 1869. This work has lately been reissued, and can be purchased for a few pence. There still remain, however, some conspicuous injustices. Of these, the most conspicuous are to be found in the divorce laws. The lunacy law also makes invidious and unjust distinctions, and so do the laws relating to libel and slander. The same is true in the case of contract law—"A wife cannot bind her husband's estate, but a husband can bind all his wife's property not being her separate estate." A man may sue in the High Court without giving security, whereas a woman may not. The criminal law distinguishes in favour of men in regard to misbehaviour on the streets. Company law shows similar inequalities.

Penalising Women Workers. Women workers are at a grave disadvantage compared with men workers as regards their hours of labour, though this case is in a different category because the restrictions on women's labour have all been devised in their own interest. But an essential injustice is involved in the fact that the women are allowed no voice in the making of these laws.

As regards wages for work, women suffer severely, quite independently of the quality or quantity of work that they do. They are paid less, simply because they are women. This is countenanced not merely by an enlightened body, such as the Manchester Education Committee, but also in the Government services, such as the Post Office, where "women are invariably paid less than men for precisely the same work."

There is at present before Parliament a proposal—the Local Authorities (Qualification of Women) Bill—which proposes to remove a host

of disabilities under which women labour in regard to public work. Says Lady Grove ("Fortnightly Review," July, 1906): "It will enable electors to place directly elected women on education authorities, and to secure their services in other matters of local government, such as the housing of the poor, the looking after public lodging-houses, the management of the female side of lunatic asylums, the regulation of the employment of children, provision for the prevention of cruelty to children, the supervision of industrial schools (containing children from three years of age), the supervision of midwives and of baby farms, of homes for inebriate women, of police courts and police court waiting-rooms (outside the metropolis), and generally to secure their co-operation in matters relating to the public health. Could women ask to be allowed to do anything more womanly, more sane, more profitable to themselves and those they are willing to serve than to fulfil the offices above enumerated? That they have done it well is not only not disputed, but paeans of praise are raised by all intelligent, honest men who have worked on public bodies with women."

It may be thought that Lady Grove is a biassed witness, and therefore we may quote the opinion of Lord Reay, Chairman of the late London School Board, who, after describing the invaluable work done by a lady for that body, says: "It should further be noted that much of the work described could only be done by a lady, and that the exclusion of ladies would deal a fatal blow to the efficiency of this Board."

The "Woman Question" Abroad. Certainly Lord Hobhouse seems to have been justified in using the term "criminal imbecility" to describe the action of the late Government in refusing to allow the State to profit by this almost unlimited source of public beneficence which is at present lying idle, absolutely wasted. And, as has been said, the injustice to the State is almost greater than the injustice to women.

Before we consider the present form which the woman question has taken in this country, it will be well for us to acquaint ourselves with the extremely interesting movement among women on the Continent, notably in Germany. We shall see that this has taken a form of its own, and further, we shall see that that form can find abundant biological warrant. It is, in the first place, not at all what we understand in this country by a "woman's rights movement." It does not concern itself with the obtaining of the franchise, but "is based on the demands of the woman as mother," and "so far from making as its ideal the imitation of men, bases itself on that which most essentially marks the woman as unlike the man." The most characteristic organ of this movement is called *Mutterschutz*—which means the protection of the mother. In discussing the main characters of this movement we are indebted to a recent article by Mr. Havelock Ellis. He takes as its spokeswoman the Swedish woman Ellen Key, who at the outset seeks to distinguish her ends from the aim of women in America. She will have nothing to do with the tendency for woman "to seek to capture the activities which may be much more adequately filled by the other sex, while at the same time neglecting the far weightier matters that concern her own sex." She declares that such women are birds that may have a gorgeous plumage, but cannot sing. "Man and woman are not natural enemies who need to waste their energies in fighting over their respective rights and privileges, but in spiritual and in physical life they are only fruitful together." Ellen Key regards the elevation of the race through their influence as the proper function of women in society, and Mr. Havelock Ellis has pointed out the manner in which her ideas are complementary to those of Mr. Francis Galton, to whose "Eugenics" a reference has been made in PSYCHOLOGY.

The Proper Sphere of Women. We would desire the reader to pay special attention to the main characters of the feminist movement in Germany, because it is so admirably in accord with the fundamental facts of biology. What could possibly be wiser, for instance, than the recognition of the fundamental truth that "women must use their strength in the sphere for which their own nature fits them. Even though millions of women are enabled to do the work which men could do better, the gain for mankind is *nil*. The physical and spiritual elevation of life is women's supreme work, and to send them away from the home to do men's work is, she declares, as foolish as to set a Beethoven or a Wagner to do engine driving."

We cannot do better than quote the conclusion of Mr. Havelock Ellis's valuable article. Speaking of the women of Germany, he says:

"They are not imitating the methods of their Anglo-Saxon sisters; they are going to work in their own way. They are spending very little energy in waving the red flag before the fortress of male monopoly. They are following an emotional influence which—strangely enough, it may seem to some—finds more support from the biological and medical side than the Anglo-Saxon movement has been able to win. From the time of Aristophanes downwards, whenever they have demonstrated before the masculine citadels, women have been roughly bidden to go home. And now, here in Germany, where of all countries that advice has been most freely and persistently given, women are adopting new tactics; they have gone home. Yes, it is true, they say in effect, the home is our sphere. Love and marriage, the bearing and training of children—that is our world. And we intend to lay down the laws of our world."

The Protection of Motherhood. We may briefly note the directions in which in various parts of the world society is beginning to pay proper attention to the protection of motherhood. Only the smallest beginning has yet been made by legislation, and we have to recognise that, as is hinted by Lady Grove, there tends to be a conflict of interests, some declaring, for instance, that the law which does not permit a woman to work in a factory until three months after the birth of a child constitutes a handicap and an injustice, while others will regard it as a protection of the woman by society. We may certainly take it, however, that before very long

we shall recognise the wholly vicious character of married woman's labour, and even before that is generally recognised, we shall at least follow in this country the example of Switzerland, where no pregnant or nursing woman is allowed to work for several weeks before or after her confinement.

There is at the present time in this country a great deal of opinion in favour of the establishment of municipal *crèches*, and of school meals for children, on the ground that infants and children cannot properly be attended to by mothers who have to work in factories or elsewhere outside the home. Without entering into any argument for the present as to such institutions as the municipal *crèche* or the school meal, we must at least go back to our first principle that neither the municipality nor the school, but the family, is the unit of the State, and that the tendency indicated by these devices is in the direction of weakening the family, strengthening the deadly grip of married women's labour upon the heart of society, and cannot be regarded as in any proper sense a means of relief or protection for mothers. It only tends to make more secure the bonds of their unnatural slavery.

The Difference Between the English and German Movements. In this country the woman question is very different indeed in form from that which we have seen in Germany. It cannot claim, as can the German movement, hearty medical and biological support. The rights for which the women tend to fight in this country are not the rights of a woman to be a woman, but, apparently, the rights of a woman to be a man. That, perhaps, expresses accurately enough the difference between the English and the German movements. This is the more remarkable, perhaps, because woman has obtained a far greater proportion of her political rights in this country than in Germany. But there is no need to linger any longer at the outskirts of the question; let us frankly ask ourselves what opinion, as sociologists, we can form as to the question of the franchise for women. There is not the slightest hope of women obtaining the franchise in Germany for many a long day, and they do not even seem desirous of possessing it; but in this country the franchise is the centre of their ambition, and therefore the question may be stated in the simple form: Are men wise and right in denying to women what they formally ask for? It is admittedly a case of the exercise of male power. Is it warranted?

Should Women Vote? Now, this is a question on which opinions will differ for perhaps another generation, and we have to recognise that sociological opinion is divided. Here, the present writer can only state what he believes to be true and reasonable arguments. Herbert Spencer, who can be instantly acquitted of any bias against women by all who know his ideal of womanhood and his writings, was of opinion that women were not entitled to the franchise because they cannot bear arms. This objection is frequently quoted even at the present day. The man who votes for war knows that he may have to go and fight himself; whereas woman may vote for war but may stay at home. To the present writer, at any rate, this argument is absolutely incomprehensible. It seems to him that woman suffers more than man from war, even though she does not herself bear arms; and that, on the whole, her votes would tend to be cast in favour of peace—notwithstanding the apparent assumption that, if she had a vote, she would be liable to vote for war, knowing that her own skin was not threatened. Further, it seems to him that women perform services to the community at least equal in value, though different in kind, to the services of the soldier, and it seems to him to be a novel reading of history to suppose that the men who make wars are commonly to be found in the fighting line.

Would the Franchise Spoil Women? There may, of course, be sound arguments, unfit for laughter or tears, against the admission of women to the franchise if they desire it; but if there are such arguments, it is a pity that they are not brought forward into the light. That which we have examined is apparently regarded as the most valid one. Those commonly adduced have only to be named to be scorned. Exponents who have never said a word against married woman's labour, or who themselves employ such labour, will be heard declaring that if a woman votes—the process occupying one morning, say, in five years—she will be unable to attend to her own business. Let those who know Staffordshire and Lancashire appraise this argument at its due worth. There is also the argument that women are incapable on intellectual grounds. Let those who know for what, and against what, the men of this country have voted in times past contemplate this argument. There is also the argument that intermixture with politics causes feminine deterioration. This is commonly advanced by distinguished persons whose wives are Primrose Dames!

The Best Women Will Use It. If it were to be the case that the possession of the franchise would turn into political nuisances women who would otherwise be happy and useful wives and mothers, no further discussion of the question would be possible. But where is the psychologist to be found who would suppose that such a radical change could be so wrought? Indeed, when women's franchise is a fact it will doubtless be found that a very large number of women do not want it, and will not use it, as in New Zealand. This, by the way, has been advanced as an argument for the exclusion from the franchise of women who *do* want it. The argument is in worthy company and may pair off with that which avers that the giving of a vote to wives would lead to the disruption of many happy homes! It will doubtless be found that the franchise is chiefly exercised by that class of elderly, sober, experienced women for whose potential activities society makes so little provision at the present day. To suppose that their influence would not make, on the whole—as it does now with less effect—for that righteousness which alone exalteth a nation is to be offensively ignorant, or still more offensively dishonest.

Continued

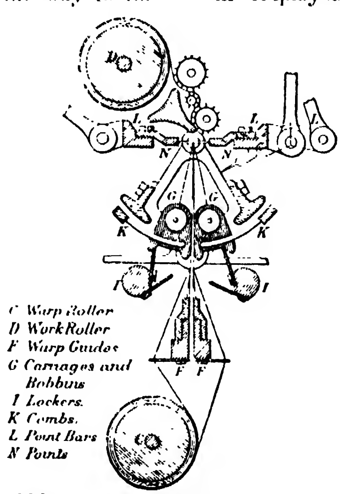
Continued from page 4881

THE LACE FACTORY

Lace-making Machinery and its Operation. Curtain Looms. Lace-finishing Processes. Warehouse Finishing

By W. S. MURPHY

IN the year 1813, John Levers, a loom builder of Nottingham, took out a patent for improvements to be applied to the lace loom. The main idea of Levers was to obtain full control of every part of the machine. As a means of effecting his purpose, he placed all the bobbins in one tier, a thing which Heathcoat had seen to be an advantage, but despaired of accomplishing. Simple though it seems, this alteration involved considerable changes in the structure of the loom and in the form of the bobbins and carriages. Most important of all, it opened up the way to the application of the jacquard to the lace loom. Desiring to place double the number of bobbins in the same space as those on the bobbin-net machine, Levers needed carriages half the thickness of those used by Heathcoat. To put twenty to thirty carriages bearing bobbins containing thread within an inch of space required very fine workmanship on the carriages and immovable steadiness in the structure of the loom. That Levers accomplished his purpose was largely due to the fact that he had the services of Thompson, an unrivalled mechanic and himself an inventor of no mean ability. In structure and workmanship the bobbin and carriage of the Levers loom set a high standard, which has ever since been maintained. In its first form the Levers loom was a circular machine of which we give a diagram [224], illustrative of its details. As will be observed, the carriages, G, differ in shape from those of the later machine, and the warp guides, F, act in place of the slide bars.



224. SECTION OF CIRCULAR LACE LOOM

The Standard Lace Loom. Every practical man knows that there are other looms in use besides the Levers patent. For plain mesh and curtains these fine machines are not necessary, and we have consequently many cheaper looms of simpler construction. We think, however, that a thorough study of the Levers loom, as improved by many inventors during the nineteenth century, and with the latest jacquard appliance, is the shortest way of acquiring a working knowledge of lace machinery and manufacture.

Bobbin and Carriage. Taking the weft first, we shall see it safely put into the loom, and then look to the warp. The carriage [225] is a piece of fine steel, shaped like a truncated triangle, with the base extended and made circular. From the extensions at the base two horns, C, come up, the purpose of which is to catch into the holders of the landing-bars within the combs. The centre of the steel plate, A, is cut out in the form of a circle, with the under half flanged. At the side of this circular hole a nibbed spring, B, is riveted. Through the head of the plate a small thread-hole, D, is drilled. In this shape the carriage is ready for the bobbin.

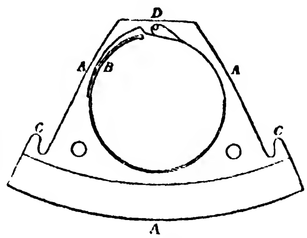
Winding the Bobbins. Some of these looms employ as many as 3,000 bobbins at once, and use the thread with which they are filled with great rapidity. A quick bobbin-winder [226] was thus required, and came forth in such efficient shape that hardly any alteration has been made on it during the past sixty years. At the end of the winder a warp beam, A, is slung, its motion controlled by two cone pulleys, *d e*, so that its speed may be graduated as the warp is driven off. From the beam the threads are led across a blackboard through a series of brass guides, *b c*, and on to the bobbins, *a*, closely set on a spindle, B, extending from the driven pulley, C, at the side of the frame. This spindle is square, and fits through a square hole in the centre of the bobbin. It is needless to remark that driving force is thus acquired without further trouble. As many as 300 bobbins can be wound on this machine with the greatest accuracy, the stop motion so common to all yarn-winding frames being fixed in it.

Filling the Carriages. Insertion of the bobbins into the steel carriages is not a very simple operation, though performed by boys. Fillers must be very swift and dexterous. Holding back the spring, the lad adjusts the double disc in the flange of the circular opening in the centre of the plate, draws forward the spring, and brings the thread through the small hole in the top of the carriage. This done, he slings it on a wire for bearing to the loom.

Combs and Bars. Excepting that they are finer and more accurately balanced, the combs [224 K] and landing-bars of the Levers loom differ little from those of the bobbin-net loom already studied in detail.

Warp. Having placed the weft in position, we must now look to the warp and its controlling

appliances. It may have been, and in practice always is, put into the loom first; but that does not concern us. Here we come upon an essential difference between the Levers lace loom in present use and the bobbin-net loom. The warp of the latter was wound on one beam, while the warp we are now examining is divided up into portions and wound on many beams. Tin tubes about 2 in. in diameter, with gudgeons on each end, these warp rollers may be wide or narrow, numerous or few, according to the pattern to be woven, for at this point in the lace loom we encounter the principle which every weaver in all the textile trades must thoroughly understand. The manner in which it is woven determines the length of warp taken up. Different patterns take up different lengths. Warps which vary in the take-up cannot be drawn from the same beam, therefore we require at least as many warp beams as the pattern uses differently. A very elaborate pattern may require as many as 300 warps, or warp rollers, piled up in the bottom of the loom in tiers of 100 each. On the other hand, a narrow lace, in which there are 100 warp threads, and woven 60 breadths in the loom, has 6,000 warp threads in all; but the variation in the pattern cannot affect more than 100 threads, and, therefore, 100 warp beams, containing 60 threads each, will be sufficient. When the proper number of warp beams have been placed in the loom, the tension springs and weights are adjusted according to the amount of slackness or firmness each different thread must possess—according, that is, to the length of thread to be given off at a time. Then the threads are led through the slide bars and up on to cloth or work beam.



225. BOBBIN AND CARRIAGE OF LEVERS' LOOM

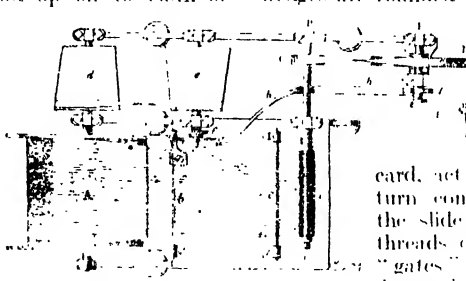
Slide Bars. Slender strips of fine steel, perforated for the passage of the warp threads, the slide bars extend through the whole width of the loom. At one end the slides are secured by spiral springs, and at the other end the jacquard guides hold them These bars perform in the lace loom the same office as the healds in an ordinary cloth loom. Each bar is threaded only by those warp threads designed to act in the same manner throughout the whole pattern. Being very slender, as many as 100 can act within an inch of space. As the slide bars can be moved either backwards or forwards over a considerable space, they impart to the warp a wonderful mobility.

Point Bars. Once again we find appliances already utilised in almost the same manner in the bobbin-net loom. One thing is to be noted, however. Because the slide bars and the jacquard make play on the warp threads, the duty of these bars (224L) is somewhat lessened. In the main their office is to lift up the course of twisted weft threads to make room for the next course.

The Lace Jacquard. In the operation of the jacquard we obtain the clearest view of the action of the slide bars, and understanding thereof. We must first note that the lace-loom jacquard differs in almost every particular from the apparatus of the same name and principle used in cloth weaving. Here are no cords, no hooks, no lifting gryfe, and no sets of pendant wires. The jacquard is placed at the side of the loom. As a rule, the jacquards on the fancy lace looms are double; sometimes a third is introduced to manipulate the thick threads which so often border designs. For our purpose, the double machine will serve.

Cards and Cylinders. About 30 in. long and $2\frac{1}{2}$ in. wide, the cards are perforated with as many holes and as variously as the design requires. Strung into the form of an endless belt, the cards are hung on sexagonal cylinders, which sit within the frame of the machine. The cylinders are actuated by a rocking shaft, which turns and alternately raises and lowers them, enabling them to bring the cards into contact with the wedges which act on the needles, or slides, and at the same time change the cards.

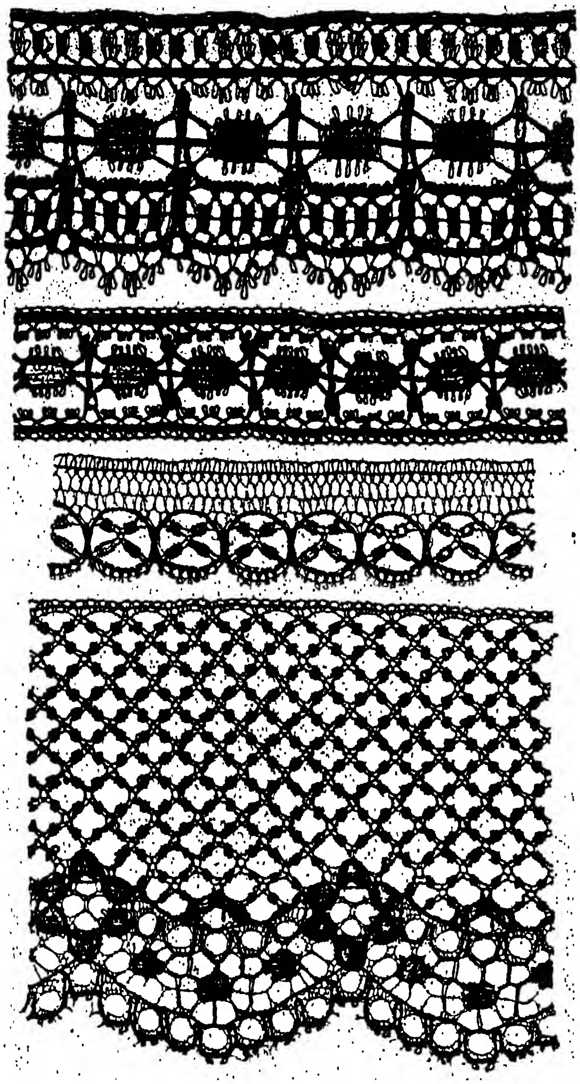
Wedges and Needles. On each jacquard there is a series of five wedges, graduated in size from one capable of making a slide bar pass two threads to one with the power of covering eight such spaces. The ends of the wedges are rounded to fit into the perforations of the cards, and they are held in place by small flat springs. As the cylinder moves up with the card, all the wedges which have no corresponding hole in the card, act on the needles, which in turn communicate the motion to the slide bars, and shift the warp threads one, two, four, or as many "gates" as may be desired and designed.



226. BOBBIN-WINDING MACHINE

Minor Parts. By means of cross bars and springs the working parts of the jacquard are kept in position and receive movement. The slide bars have studs upon their ends which grip into the wedges described. The whole mechanism is enclosed in a very strong frame, which obviates the risk of vibration.

The Lace Loom in Operation. Having obtained a knowledge of the parts of this machine, we can now observe its working with interest and understanding. When the loom starts, the jacquard brings the foremost card into position and the cylinder rises, acting on the needles and wedges which draw the slide bars in the various



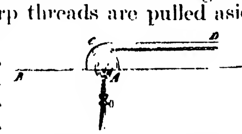
227. GUIPURE LACE MADE ON LEVERS' LOOM

degrees of obliquity. At the same time the bobbins and carriages are crossing from side to side, leaving behind them filmy lines of twining and twisting thread, mingling in mazy order with the pulsing threads of warp. Considering the manipulative power exercised by the "shogging" comb bars, the changing carriages and the slanting slide bars, one almost believes that the fingers of the pillow-lace maker have been for ever superseded. As each line forms, the point bars gently lift the threads up towards the cloth beam to leave room for the coming course. When it is considered that all these movements are completed in the space of half a second, and constantly repeated, the effective productiveness of the lace loom may be imagined.

The variety of laces produced can hardly be calculated, and the delicate fabrics we show [227] have been photographed from the ordinary productions of a lace factory.

A Fine Machine. During the past forty years little or no advance has been made in the general structure of the Levers loom. The loom we have examined has some improvements on the original machine, but these relate mostly to the jacquard and the equipment for power driving. The main structure remains almost the same as when Levers left it. Written more than forty years ago, this description, by Felkin, is, in its main particulars, true to-day: "Levers' machines are made as coarse as five-point gauge and as fine as fifteen-point. A ten-point gauge requires 20 warp threads to the inch when a full warp is wanted. In this there will be 20 bobbins and carriages in the inch single tier on the central comb bar. Besides these, in making fancy goods, there will be thick threads moved greater or less distances sideways, according to the weight on each thick thread beam. Of these there may be 40 or more to the inch. Where there is no net in the ground there will be no warp. The lace is produced in that case simply by the gaiting (shogging) movements from side to side of the thick threads, and the twisting movements of the bobbins and carriages to and fro as they pass through and around the thick threads. The machine will make 80 or 100 of these backward and forward movements in a minute, with their complement of relative motions, or about 1 in. in length, of closely woven lace, the whole breadth of the machine, however wide, in each minute."

Curtain Looms. An important branch of the lace trade is curtain manufacture. For the highest class of curtains, the loom we have just been studying is used; but for the cheaper class of work an older model of the lace loom is employed. Upon these looms the jacquard apparatus is hung above the cloth beam, just as in an ordinary weaving loom. But a curious difference occurs, which will be readily appreciated. Instead of coming straight down, each cord directly to its warp thread, the cords are crossed, the obvious effect being that the perpendicular warp threads are pulled aside to the extent desired. In other respects, these looms are simpler. Guide bars are substituted for the slide bars, and instead of the numerous small warp beams, one beam supplies the warp for each breadth of curtain. For the rest, the common curtain loom differs very little from its superior fellow. Some of the curtain looms are very large, the largest weaving 10 curtains in one breadth.



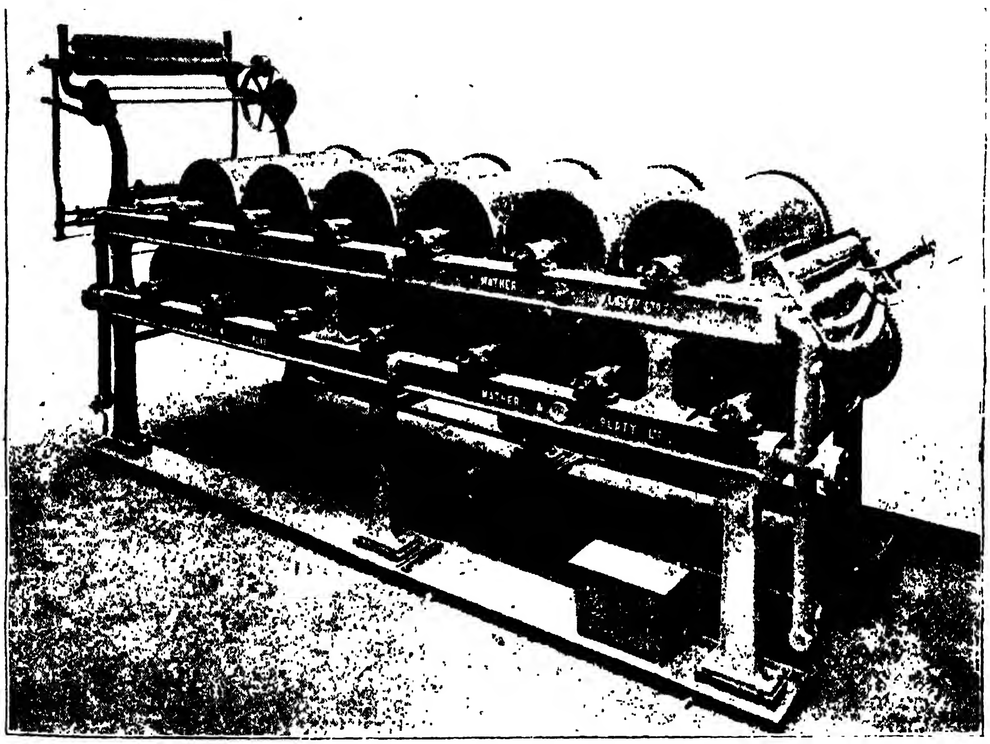
228. HALL'S GASSING APPARATUS

Inspecting and Darning. The finishing proper is very seldom done in the lace factory. Two separate processes are involved, the one being carried on in the bleaching works, and the other in the warehouse. One finishing operation, however, must be done in the lace factory, and that is the inspecting and darning. The newly woven fabrics are carried on the beams into the inspecting room. The beam is slung on the one side of a smooth table. At the other side the inspector stands, and draws the lace over the smooth surface, marking every blemish as it ppears. Thus marked, the laces are passed over the darners. At one time, all the darning as done by hand; but now sewing machines re employed which imitate accurately the meshing of the lace. If the pattern is seriously defective, the hand darner must be called in to supplement the machine.

Lace Bleaching. This is a distinct branch of the bleaching trade. It is much shorter than the ordinary bleaching process. The object of the lace bleacher is simply to give a pleasing white colour. Chemical purity is not aimed at.

Gassing. Gassing is practised by nearly every textile manufacturer; but it was specially invented for lace by Samuel Hall, of Nottingham. Even after hot-plate singeing the lace retained a cloudy appearance, because of the gauzy nature of the fabric, showing all round the threads. A flame which would go through the fabric was needed, and this Hall accomplished by inventing an apparatus which drew the gas up through the lace [228]. His invention was crude, and it has long been superseded by appliances more accurate and scientific; but the principle remains the same. Two essentials are common to all the forms of gassing machines—the decarbonising of the gas by mixing air with it, and the rapid passing of the fabric, B, through the flame, A.

Bleaching. Every bleacher has his own favourite method and materials for whitening lace goods. Various formulæ are given in the Dyeing section of this course. Our duty is simply to observe closely the practical operations. Steeped in bleaching liquor for a period varying with the weight of the fabric, the lace is washed clear of the liquor in circulating vats. Gently squeezed from surplus water, the lace is taken from the washing machine and laid in the dollying tubs. The model most approved is a round tub in which smooth-faced beetles lift up and down on the fabrics immersed in a solution of soap and blue. The tub goes round, the beetles tread the liquor through the lace. A pair of rollers at the side of the tub, when the dollying is complete, give the lace a parting squeeze, sending the liquor back into the tub and the lace out into the trolleys which bear the filmy mass off to the washing troughs. These are wide tanks ingeniously arranged. A constant circulation of water is kept up, by the equal outflow of dirty water and the inflow of clean water. The laces enter at the side of the outflow, and pass round rollers, which bear them onwards to where the clean water is pouring in. Thus cleaned, the lace goes into the drying-room, where in a high temperature, and by drying

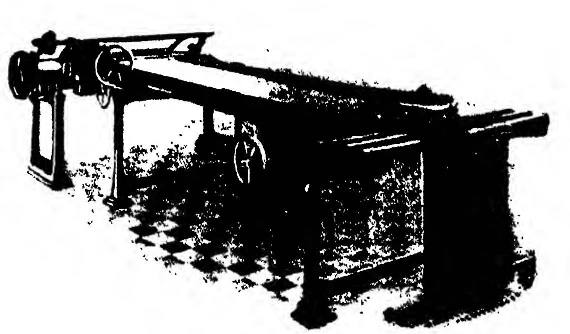


229. LACE-DRYING MACHINE

machines, centrifugal or stove, they are made dry. The newest form of contrivance is the horizontal drying machine [229], in which the lace is wound round heated cylinders.

Starching. Fine point and pillow laces are usually starched by a hand process. On tables covered with smooth canvas, the starch, made up of fine wheat extract, alum, and smalts blue, is thinly spread with brushes. Then the lace is carefully laid on, and brushed down smooth. With heavily-figured laces this is particularly effective, the figures showing out very white and the meshing appearing slightly shaded with blue. Heavy curtains and other factory laces are put through the starching machine.

Stentering. After starching, it is essential that the laces should be at once set into the proper shape. Lace depends for its beauty largely on the manner in which the threads are set. The weaver and designer can provide us with certain forms and combinations, but these must be confirmed in the finishing. In this process, the stentering room is very important. Curiously enough, stentering machinery such as is used in many cloth factories was not favoured by the lace finisher for a long time; but the same kind of machine [230] is now in extensive use. Lace stentering is practically a hand process. The frames are wooden rails, fitted with screws so as to be gradually extended. Within the rails little hooks are set. On these the stenter workers link the lace web, and stretch it out, assisting to free the threads which may have knotted by beating with long wands on the stented fabric. When a good piece has been got on the frame, the screws are brought to bear, and the frame widened out to the proper stretch of the lace. This must be done with great care, so that all the threads may lie straight, and according to design. Means are usually provided to make the stentering room a drying room as well. In some places great fans revolve above the stentering tables, while steam pipes round the sides make heat. Other finishers put the fans and the steam pipes under the stentering frames.



230. STENTERING MACHINE (Mather & Platt, Ltd.)

Spraying, Calendering, and Pressing. These operations have already been studied at some length in the cloth-finishing section, and need hardly be gone over again. The instruments are the same, though in practical handling attention must be paid to the delicate character of the fabric.

Warehouse Finishing. When the lace has been well dressed, it is not ready for the market. Edgings, trimmings, frills, and all that numerous range of laces so daintily fit for decking the attire of ladies, are woven by the web, and have been dressed in that condition. The warp threads connecting one strip of edging with the other have to be "drawn," and the strips separated. This work is often given out to home workers.

Dressing. Some of the finer classes of lace are dressed in the warehouse. The process is not unlike the starching already noted. In an industry producing so wide a variety of fabrics no common routine can be prescribed. Many Nottingham lace manufacturers combine dressing with stentering. The girls hook the edges of the lace on to the frame, lay the starchy substance along the edges, and spread it across the whole breadth with brushes.

Mending. The loom is not yet a perfect machine, and its produce partakes of the imperfection incident to most things earthly. Threads break, loops slip, and stitches miss. The menders who remedy these defects are practically skilled lacemakers; they fill in with the hand what parts of the fabric the loom has left out.

Clipping, Scolloping, Grafting, Braiding. Most of the finishing processes of lace manufacture are skilled operations which can be learned only by practice. By means of sewing machines, the curtains are edged and braided, the borders grafted, and the embroideries put on the plain nets, or the initials and other ornaments inserted into the lace handkerchiefs. Here, the sewing machine manufacturers have scored an undoubted triumph. By means of special needles and guides on the sewing machine, the lace embroiderer is enabled to produce figures and traceries with great rapidity and accuracy.

General Warehouse Work. The organisation of a lace warehouse is a matter of no little difficulty. It is worth noting that most of the large warehousemen are old firms, which have grown up with the industry. Thus, department has been added on to department as the business has developed. In the multiplicity of small departments it is easy to lose money without perceptible fault on the part of anyone. For it must be noted that these warehouses employ machinery of various kinds besides sewing machines capable of even making lace. Taping, scolloping, tucking, pressing, and winding machines make up miles of laces of various kinds and breadths. Making-up laces is a special branch, requiring taste and skill.

Continued

AUCTIONEERING

Essential Qualifications of an Auctioneer. Salaries. Drawing up Inventories and Catalogues. Sales by Auction. Accounts

By JOHN COX

AUCTIONEERING is a profession which may be said to have been born of Commerce. Where there is barter there will be an auctioneer, and from the inherent desire of us all to obtain the best market value for that which we wish to sell, it is but reasonable to suppose that the profession of auctioneering is one which may expect the support of traders in all times.

The vocation is essentially one for the man of education. The curriculum of any public school forms the finest groundwork upon which the training may be founded—that is to say, the instruction which is obtainable on the commercial side of such school. Our student should write well and fluently, and his training will be most usefully supplemented by a course of typewriting and shorthand. A young man requires, further, a natural aptitude for quickly grasping situations, an abundance of tact, and some ability to face an assemblage of his fellow men. In this respect, advantage may be taken of the opportunity of entering a debating society or a local Parliament, as it will be found that the experience in public speaking gained in this way is highly beneficial. One has but to be a fluent and quietly convincing speaker to command attention. It is superfluous to remark that energy, perseverance and intention to succeed are half the battle, and a scrupulous regard for truthful and straightforward dealings should complete one's initial stock-in-trade.

Entering an Office. The all-important business of entering an office will next command our attention. Our beginner should ask himself whether he prefers a town or country practice, and, whatever the choice, he should endeavour to enter an office where he is likely to gain a good all-round experience. Those who are able to afford a fee for articling should know that there are some self-styled auctioneers whose very existence depends upon their obtaining articled pupils. Of practical work there is little to be found in such offices, and it is wise to seek a well-known firm, in one's locality, for choice, which apparently offers the most advantages. The best course to pursue is to enter a firm with a fair all-round connection, and to work one's way up. This is the best test of aptitude, and the market is not overcrowded to the man who can honestly say: "I know every stage."

Salaries. Regarding remuneration, an articled clerk is usually paid from 8s. to 12s. weekly, but this is governed by the amount of premium paid and general ability shown. A lad may enter an office at anything from 5s. to 8s. weekly, and may work his way up by stages to the position of improver, earning perhaps 15s. or £1 weekly and commission, at the end of, say, three years. The commission to a young man of ability will make a very fair showing, and if he be thrifty, and fortunate enough to be with a firm doing a fairly extensive business, he may, during the course of the ten years which he must expect to devote to his business before launching out on his own account, put by enough to start him in business. So, then, he becomes a junior and senior clerk in turn, earning from 30s. to £3 a week, according to his ability; and, in the course of time, he may be earning anything from £150 to £250 a year in salary and commission as a managing clerk.

It is not necessary to give particulars of the office routine, but it should be said that our junior must master the use and indexing of the various letter copying books and understand the standard system of filing, docketing and indexing. He must be wholly systematic in all things, and should pay the very greatest care to detail. Order in an auctioneer's office is absolutely essential, and one must pay strict attention to instructions, for a mistake in a small matter may prove costly.

The Inventory. During the course of his early career a beginner will doubtless have to accompany his senior to make an inventory. He must not despise the inventory. It serves as a good stepping-stone to the making of the catalogue, and therefore its points should be closely noted. The occasions which call for an inventory are many. It is required upon the letting of a furnished house, a copy being made for the incoming tenant to sign, one being retained by the auctioneer to enable him to check the contents of the house at the expiration of the tenancy. One is also required to be taken of any furniture comprised in a valuation for probate; for attaching to a fire policy to settle disputes arising on claims; on the outgoing of the owner of a business where he sells his chattels at a valuation, also in partitioning goods upon the demise of a late owner.

Armed, then, with the familar inventory book, we proceed to, say, a house of fair size. A note must be made of the place of visit and the purpose thereof, the date and the name of the clerk making the inventory. This is written at the head of the page, and, after making a general survey of the premises, we proceed to the top floor of our house and begin with the minor rooms, usually bedrooms, and work our way down the house, floor by floor, room by room. There is a method in making an inventory, as will be seen. We start with the most important room on the floor, naming it Left Front, Right Front, or Back, as the case may be, which designations are intended to be self-descriptive, or, in the case of a larger house, by its number and situation, if it be in the main building, right or left wing; so that if our inventory comes into use at a future date, it will be an easy matter to recognise the various rooms.

Procedure. The procedure differs in some firms, but the object is to make a list of every article the house contains. We begin, then, with the carpet, rugs, the fireplace furniture, followed by the window furniture, the suite and any other articles upon the floor and those around the room against the walls, beginning, for this latter item, on the right-hand side of the door as one goes into the room. We finish up with the pictures, china, and wall ornaments in the same order. In the case of

the bed-rooms, it will be found expedient to deal with the bed and bedding just after the window furniture has been noted and before dealing with the suite.

This method applies to all rooms, and it will be found that with a little practice the missing of an article will be a rare occurrence. After a few preliminary visits of the nature mentioned, the student will be enabled to attempt an inventory on his own account, and if he faithfully adhere to his system, the attack of even a mansion, with its walls covered with bric-à-brac, will not prove an impossible task.

Our beginner must take careful note of the descriptions applied to the various articles, and their period. He must learn to distinguish Turkey, Axminster, Brussels and tapestry carpets, rugs and mats. He must become an adept—in the course of time—in describing the woods and chinas customarily found in an ordinary house; he must be able to differentiate between cloth, damask, tapestry, silk, embroidery, lace and the like, and he must not be disheartened at the apparent magnitude of the task.

Information in Catalogues. We cannot hope to convey any substantial idea of the multitude of different descriptions which an auctioneer daily calls into use; but we can, and shall, point the direction whence the required information may be gradually assimilated by our pupil during his early days. He should not be above studying the contents of the leading furnishing and dry goods firms, and he may gain a mine of information from a well-arranged, illustrated list of any such house, especially when it is borne in mind that these catalogues are prepared by men of long experience. In making catalogues, to which we shall presently allude, one may even quietly take a leaf from the book of the head porter, who is usually a man of wide experience in descriptions of furniture and such things. In short, he must consult every available fount of information, using only the knowledge he acquires from hearing the inventory made by his senior as the foundation for further information. Our rising knight of the hammer must remember that he, of all men, must not only know the proper description to be applied to everything, but, in the course of time, will be required to offer expert opinion as to its value.

After the visit to the house just referred to, we shall require a fair copy in duplicate of the list of articles. This is done in the office on specially ruled forms of inventory paper, familiar in every firm, and on this a title-page is set out giving the address, purpose, name of firm making the inventory and the date, followed by a careful description, copied from the inventory book, of all articles properly allocated to their respective rooms. In this list, both sides of the paper are written upon, and the whole is bound up in a cover of the same size as the paper, bearing an index label.

We have now dealt with one of the most troublesome matters to a new-comer into the business; but, with care, knowledge will gradually assert itself, and if a point is made of never applying a description until one is assured of its accuracy, proficiency will be all the sooner gained.

Cataloguing. Cataloguing is the mode of assembling furniture for the purposes of sale. In the auctioneer's profession the catalogue is somewhat similar to the inventory, the same system being adopted in regard to its compilation, with the important difference that the articles enumerated are collected together, accurately described, in the form of a "lot" which, in the opinion of the auctioneer, will constitute a saleable parcel of goods at auction. The rooms are taken in the order and method named for inventories, the goods described, and a rough catalogue made out on single sheets of foolscap, a space being left between each lot as the articles are enumerated and the whole household contents brought in. It should be the aim of the auctioneer to lot his articles so that a desirable, or, what may be better described as a saleable, article is included with an unsaleable one, so that one portion virtually sells another. This is a rule that only applies to the multiplicity of oddments which are found in every household. The point is to avoid putting an article up by itself when, from the nature of the thing, this is inadvisable, but to add it to another lot so that there is a fair probability of the whole securing a good bid. It would be bad policy to lot a carpet with a chest of drawers, because these two things are fairly certain of selling separately, and if of fair quality would make the required guinea lot; but, in the same room, it would be found necessary to lot a fire-screen, a towel-airer, a hand glass and a couple of slip mats, so that one could sell together that which it would be absurd and perhaps useless to lot separately. The auctioneer must invariably aim at making up a lot of sufficient size, applying his discretion to the character of the goods being sold, and remembering always that he has to sell *everything*.

Numbering the "Lots." Having written out the catalogue and made up the various lots, we proceed then to number the latter, not forgetting to leave one or two blank lots at the end of each room to provide for the inclusion of any article which may, at the time of the sale, have been inadvertently missed. With a title-page, setting out the principal and interesting pieces of furniture offered for sale, the draft catalogue is sent to the printers, conditions of sale being added, which may be of a stock nature or specially adapted to the particular needs of the articles being sold. Eventually the proofs are gone through and the matter is concluded.

The announcing bill will be conveniently drawn by making a double demy replica of the front page of the catalogue. It will be found that a very good auction bill can be drawn after a general survey of the property to be offered. The bill should be got out first, and duly exhibited, to give as long a notice of the sale as possible.

There are some important points to be remembered in the making of the catalogue. For instance, Turkey carpets are described in square feet, Brussels, Axminster, tapestry, and other carpets in square yards (the breadth being 27 in.). Bedroom furniture would be referred to in this way: Bedding and bed by the width, a wardrobe by its width, with the size in inches of the plate mirror in door. The washstand and the dressing-table or chest by its width, with the size in inches of the plate mirror surmounting the latter. Taking the dining-room furniture, the dining-table would be referred to by its length, with the number of the leaves up to which it extends, the sideboard by its width, and a bookcase by its length. Ornaments are taken by height; pictures as to whether they are in oils, or are water-colour drawings, engravings, or prints. The wines are added after the reception rooms have been dealt with, and are followed by the silver, which is sold at per ounce: and the

catalogue is concluded by the domestic offices, the gardens and the contents of greenhouses or conservatories. Articles found to be faulty are duly referred to by placing a small "f" in brackets after the description of the article thus: (*f*).

Our pupil would be well advised to give some time to the study of catalogues of sales by the good West-End firms of auctioneers, and it will be found that a little application to these will give a valuable amount of information which is not easily gained elsewhere.

Ticketing the "Lots." We have now to arrange the ticketing of the lots. This is done by the head porter, with assistance, if necessary, according to the size of the sale. He starts operations on the day prior to the view days. He will arrange the furniture in the order of the catalogue, and on the view day—the day prior to the sale—he, with his assistants, keeps a sharp look-out that no damage is done by visitors to the articles. On the sale day he superintends the bringing up to the auctioneer of all the lots in their proper order, taking care that he has a relay of three or four lots on the move, so that no time is wasted. Nothing is more annoying than a "wait" between the bringing up of one lot and the next.

Prior to the sale day, the desk catalogues are prepared by the clerk. One will be required for the auctioneer and one for his clerk, and they consist merely of the ordinary catalogues interleaved with specially ruled paper:

Lot No.	Amount Sold For.	Purchaser's Name.	Deposit.
66	13 10	Martin, G. J.	1 7 0
82	3 15	Morecambe, H. R.	7 6
91	2 10	Morecambe, H. R.	5 0
113	6 15	Martin, G. J.	13 6
119	3 5	Martin, G. J.	10 0
128	15	Morecambe, H. R.	2 0
129	4 10	Martin, G. J.	9 0
189	1 5	Martin, G. J.	3 0
268	1 15	Morecambe, H. R.	5 0

As will be seen, the first column is for the lot number, which is written in opposite to the corresponding lot number in the printed portion. In the second column are written the amounts the lots are sold for; in the third column the purchaser's name, and, if necessary, his address, while the last cash column is appropriated to the entering of the deposits paid.

The auctioneer must exhibit under his rostrum a tablet setting out his full name and address, and there are penalties attaching to an omission in this respect. He must also have at hand his auction licence, which costs £10 annually, renewable on July 6th in every year; and he then proceeds to open the sale by simply asking a bid for Lot 1. The lots are, as a rule, disposed of at the rate of one a minute in the case of household furniture, and the clerk needs all his wits about him during the conduct of a furniture sale at even this rate, although we have known many auctioneers who sell at a greater rate.

At the fall of the hammer the goods are at the risk of the buyer, and he is at once asked for his card or a deposit, and the clerk must see to it that he gets one or the other immediately.

Deposits. The deposit is governed by the conditions of sale, and is usually 10 per cent. The entry by the clerk in his catalogue of the amount at which a lot is sold, together with the entry of the deposit, is considered as sufficient proof of the transaction (fraud, of course, not being alleged). As a sale proceeds, the clerk calls into use his sale ledger, which is a highly useful account book. They are familiar in every office, ruled as under, interleaved with blotting paper, and indexed at each page.

MARTIN, G. J.				MORECAMBE, H. R.			
Lot.		Price.	Deposit.	Lot.		Price.	Deposit.
66		13 10 0	1 7 0	82		3 15 0	7 6
113		6 15 0	13 6	91		2 10 0	5 0
119		3 5 0	10 0	128		15 0	2 0
129		4 10 0	9 0	268		1 15 0	5 0
189		1 5 0	3 0				
	Balance . .		26 2 6		Balance . .		7 15 6
		£29 5 0	29 5 0			£8 15 0	8 15 0

Immediately a lot is sold, the deposit, purchaser's name, and the amount sold for are duly entered in the respective columns of the catalogue, the deposits being accountable for by the clerk. As a check upon the clerk, the auctioneer notes in his catalogue the price and the purchaser's name. An account is then immediately opened in the ledger under the index of the purchaser's name, using the proper columns as indicated above. The ledger will then set out the lot bought, the price sold for, and the amount of the deposit. There is usually sufficient time between the sale of one lot and the next to get in the deposit, enter the particulars of the transaction in the catalogue, and open or enter into the proper account in the ledger, so that if the books are properly worked, it is possible at any moment in the sale to say exactly how any purchaser stands.

As a rule, the clearing of a sale of any size is effected the day following the sale, the auctioneer announcing that the lots will be delivered the next day, say, between the hours of ten and four. It is generally found expedient to make up the sale ledger overnight.

The Ledger Accounts. We must here refer to the specimen interleaving page of the catalogue and the ledger accounts in the names of Martin and Morecambe. We see that the catalogue shows that these two purchasers have bought certain lots, and that these certain lots, together with the deposits paid on each one, are duly carried into the ledger under the respective names. At the end of the sale day we shall find it necessary to check the catalogue with the entries into the ledger, and if there be any mistake, to rectify it, going to the auctioneer's catalogue, if necessary, to obtain the correction. We then go through the ledger and cast up the price column of all accounts, and on a reserved page at the end of the book carry out the names of all purchasers with the amounts of their purchases.

We next cast the catalogue, and, all being correct, we shall have the same amount in the total of the catalogue as we have in the total of the accounts in the ledger. At the same time that we deal with the actual prices paid, we cast the amount of the deposits in the catalogue, which, of course, should agree with the total amount of the deposits carried out to the reserved page at the end of the ledger, side by side with their respective prices,

to the credit of which they stand. We are thus able to see what amount of money there should be in hand as received as deposits during the sale; and by deducting this amount from the gross amount of the sale, we see at once what remains to be collected on the following day.

Having cast the price column, it follows that we have to strike the balance in each account in order to be able at once to see what amount is due when the purchaser calls the next day to pay his balance. In the case of Martin, we see that the purchases amount to £29 5s., and that the deposits thereon amount to £3 2s. 6d., so that there is a balance due of £26 2s. 6d. We write this balance down in the deposit column, and the account is closed.

The Delivery Note. There is a small matter in connection with the accounts in the ledger which should be noted. As the day goes on there is plenty of time for the clerk to make up his accounts as he goes, therefore overnight the ledger accounts are left open—that is, minus the small double line which appears under the cast of the deposit and balance column. As the purchaser comes in to pay the balance during the following day, he hands over the balance shown to be due in the ledger, and receives his delivery note, which is merely a slip of paper with the words, "Please deliver Lots 66, 113, 119, 129, and 189" written in a vertical column for convenience of checking off, and signed by the clerk in charge of the clearing. This paper is handed to the porter, who is responsible for the correct delivery of the lots. Immediately the delivery note is handed over the clerk draws two lines under the account in the ledger which has just been dealt with, and carries the entry of the balance to the reserved page at the end of the book, opposite the name of the purchaser, as previously entered. It will thus be seen that at the end of the day the gross amount of money received on the clearing day should equal the gross amount of the sale, less the deposits received, and similarly the amount of the deposits in hand and the amount of the balances collected on the clearing day will equal the gross amount of the sale. The double lines which are drawn at the end of each ledger account will give an easy indication as the day goes on of what accounts are closed.

How to Deal with Unsold Lots. It is now a simple matter to settle the business altogether. First, a marked catalogue is prepared. This is merely an ordinary catalogue with the margins ruled in cash columns. Opposite to the lot is written the price realised for each. The total gross amount of sale will be set out in account in the usual way, and deductions are made therefrom for all expenses such as printing, posting, advertising, and commission, which, as a rule, is charged at 5 per cent. in the case of a large sale, and a cheque for the balance is forwarded to the client. It may happen there are two or three lots remaining uncleared, and it will be found expedient to get rid of any such to one or other of the numerous dealers which attend sales. These people are always on the look-out for a bargain in this way, and if it is desired to settle the matter without loss on the transaction, a little finesse will have to be employed. However, if there is a loss, this is written off the gross amount of the sale, so that it is clear to the client.

There are occasions when it becomes necessary to carry out a perambulating auction sale, in the case of, for instance:

(*a*) Live and dead stock
(*b*) Heavy stocks, plant, machinery, and the like
(*c*) Old property for demolition
(*d*) Building materials, and so on. Here it becomes necessary to defer the use of the ledger until the return to the office, but the catalogue will be used as usual, being in these cases attached to a stiff board for convenience in writing.

Sales of Real Estate. We must at this stage turn to the more important and, in a sense, more remunerative branch of the profession—sales of real estate. In the first place, the trouble attaching to sales in this department is not so great although the care to be exercised is none the less considerable.

To begin with, it is of great importance to be quite clear as to one's instructions. It is the custom to quote inclusive terms for the carrying through of an auction sale so far as regards the out-of-pocket expenses, to which expenditure the auctioneer is limited according to the properties to be submitted. For instance, he may make a charge of anything from ten guineas upwards to cover disbursements which, in pursuance to any agreement he may arrive at, would be payable by his principal in any event, in addition to his commission on the sale. He should be provided with the fullest particulars of the property and have a clear understanding on all points, including the reserve price, which is sometimes withheld until just prior to the sale.

The first matter is to determine the time and place of sale, and to arrange accordingly. In London, and, indeed, in most parts, it is sufficient to arrange the date, say, six weeks ahead, and according to the requirements of the locality to fix the hour of sale. If the property is to go to the hammer at the London Mart, a room has to be booked during the busy season sometimes two months in advance, and here a fee of 5s. is payable on booking. There are many sized rooms to be had, and, if he is at all nervous, it is advisable to secure one where the auctioneer on standing in his rostrum has his back to the light. The next matter is to pay a visit to the property and make a thorough survey, taking particular care to observe the best characteristics of the house, land, or other property which it is his object to present to his patrons in as favourable a light as is consistent with an accurate description.

The Announcing Bill. It is the auctioneer's business to draw up the announcing bill. This is an important matter, and one which is sometimes thought little or nothing of by many auctioneers. It should comprise as brief an epitome of the property for sale as possible. It is the greatest mistake to crowd it with a mass of unnecessary matter, and it should be the aim of our embryo auctioneer to draw a short and pithily-worded announcing poster, and to see that it is well set out with what we may term the "selling points" of the property properly accentuated. It must be remembered that the bill is to catch the eye of passers-by, and it is sufficient that the locality, a short description and address of the house, together with the time and place of sale, with the auctioneer's name and address, be brought out well. Endeavour to "lighten" the bill by employing two or three styles of type, and with a little patience it will be surprising how attractive our black and white poster will appear. Proofs should always be submitted to the vendor's solicitor for approval before handing the bills to the poster.

It will now be necessary to open an "Auction Expenses Account" against the client, in this style:

Sale by auction of..................................
At the London Mart...............................
on..........................190 , at ....o'clock
Vendor's Name...........Solicitor's Name.......
Address......................Address..........
Instructions given......190 ; Confirmed.......190

Commission at the rate of ....
Expenses limited to £............
Below this, of course, follows the statement:

	To hire of room at the Mart ..			
	To cost of double-demy announcing bills			
	To cost of double-sheet particulars			
	To billposting on own stations ..			
	,, ,, ,, licensed stations			
	,, ,, .. licensed railway stations			
	To billposting on property, pole boards, etc.			
	Advertising in:			
	"Times" January 1, 3, 5, 9			
	"Daily Telegraph" ,, 2, 4, 8, 10			
	"Daily Mail" ,, 3, 5, 9, 11			
	"Daily News" ,, 4, 6, 8, 10			
	"Morning Post" ,, 5, 9, 11, 13			
	"Estates Gazette" ,,			
	"Local Mercury" ,, etc., etc.			
	To Postages and petty expenses ..			

With an account such as this it is possible to calculate to a nicety what proportion of the out-of-pocket expenses are to be allocated to the different items of expenditure. As a rule, a double-demy poster will cost about 12s. per hundred, two-page particulars cost from 18s. to 20s. per hundred, according to the amount of matter and revising required. Photograph blocks cost about 10d. per square inch to reproduce on, say, 300 particulars, and line block reproductions cost about the same amount. The hire of the room costs from £2 2s. to £5 5s., according to the size and time of sale, and the rent of licensed hoardings may be 1d. per double-demy sheet per week. The usual charge by the railways is 3s. per month per station for each bill, including the fixing and removal of the board, which is supplied by the company's advertising agent. We must remember the posting of the bills on the premises, and must bear in mind that in issuing bills to the billposter of somewhat elastic conscience, it may be as well to assume that the whole of the bills may not be distributed. Having set aside a reasonable sum for postage and other petty expenses, we have a balance which we can devote to what we must regard as our most fruitful channel—Press advertising.

Advertising. We now draw out the advertisements, which, like the announcing bill, should be as pithy and concise as possible. The great dailies charge 8d. to 1s. per line of about eight words, and it is a simple matter to reckon on these lines. If an advertisement appears for a month every other day, the cost would amount to, roughly, £7 or so. A diary of the advertisements should be written up to check due insertion. Whatever, then, the limit for out-of-pocket expenses may be, we are able so to lay our plans that we are not some pounds out of hand over the transaction. Of course, there are some cases where a little speculative expenditure may be well advised, but this is purely a matter of circumstance.

Particulars of Sale. We next pass on to the "particulars." As a rule, these consist in a title-page with as many followers as are requisite, finishing up with the conditions of sale and the memorandum of agreement. The title-page may set out the general points of the estate, and if the rule applied to furniture sales be followed, it will be sufficient to introduce a reproduction in miniature of the announcing bill. Having attended and thoroughly surveyed the property and taken or checked the particulars in a note-book kept for the purpose, we inquire of the solicitor acting for the vendor how he desires the property lotted, and arrange accordingly. Each lot should be described accurately, be it land, house property, freehold ground rent, or reversion, and giving particulars of tenure, ground, or other rent, accommodation, notes as to tenancies, etc. After lotting, a draft is prepared and sent to the solicitor for approval, with the request that he will return same with the draft conditions of sale. The whole is printed, and properly endorsed with a note of the property offered, the time and place of sale, the name of the auctioneers, and that of the solicitor at the foot. When the "proofs" arrive, they have to be corrected and forwarded to the solicitor for final approval to ensure accuracy.

A note must be kept of all applications in a book—which is useful for after reference—so that, a day or so before the time of sale, inquirers may be written to with a reminder that the sale takes place on such-and-such a date, finishing with a request for the addressee's favoured attendance and bidding.

As the sale day draws round, the desk particulars are prepared for the use of the auctioneer and his clerk. These are merely ordinary particulars interleaved with ruled foolscap, partitioned off and numbered according to the lots opposite to which they appear, and enclosed in a cartridge paper cover, neatly bound up in green silk.

The Day of the Sale. The sale day having arrived, we send down by our junior a supply of bills and sufficient particulars to exhibit in the sale-room. He should arrive in good time, followed as the hour of sale draws near by the auctioneer and his clerks, with their desk particulars, auction licence, sixpenny contract stamps, name and address tablet, hammer, and a supply of bills and particulars. This latter precaution should never, on any occasion, be omitted. We ascertain that the solicitor is present with the title deeds, and perhaps discuss briefly with our client the possibilities of reducing the reserve, if it should happen that it has been fixed rather higher than anticipated.

The sale then opens. To an auctioneer making his maiden appearance the ordeal is sometimes a trying one, but any attempt at eloquent passages on such an occasion is not to be recommended. The reading through of the particulars may serve to break the ice, and it is always remarked that the conditions of sale are taken as read, but that the vendor's solicitor will answer any question arising thereon. To eulogise a property is superfluous—one is dealing with business men, and this should always be borne in mind.

Biddings are asked, and the auctioneer must begin to use his eyes well. He should endeavour to get into touch with two or more bidders who seem to desire the property, and, by setting one bid against another, should try to create a market between them. When there is a reserve, the vendor will be entitled to bid up to that reserve, provided he discloses his intention upon the conditions of sale; it is against the law to bid up a property on behalf of the vendor, where the sale is announced as without reserve. When the bidding has passed the price fixed, the auctioneer may stimulate competition by announcing the property as in the open market, and at the fall of the hammer, after asking for further advances in the usual manner, he should request the purchaser to come forward and sign the form of agreement.

The contract is an all-important document, and must, in every case, disclose the name of the vendors, or it will be void, under the Statute of Frauds. It is

executed in two parts, one by the auctioneer, and the other by the purchaser, the auctioneer being constituted the *stakeholder*. The purchaser signs over a sixpenny stamp, or the signature may be made on the mere paper, and the document afterwards impressed with a sixpenny stamp. We would here remark that in many conditions of sale there appears a clause to the effect that if any documents comprised in the title, and executed prior to the passing of the Customs and Inland Revenue Act of 1888, be found to be unstamped or insufficiently stamped, no objection (that is, by the purchaser) shall be taken. If this clause appears, the Inland Revenue authorities will refuse to stamp any such contract, and for this reason it is always as well to use an adhesive stamp, duly cancelled by the purchaser's signature. It is the custom of the auctioneer to sign his part over a penny stamp. Many purchasers refuse to accept the contract where a sixpenny stamp has not been used on the part signed by the auctioneer, who, bearing in mind his fiduciary position, would do well to make no objection.

The auctioneer, on his return to the office, makes out an exact copy of the contracts in his possession, it not being necessary at the moment for him to part with the originals, and he then forwards them to the vendor's solicitor.

The Auctioneer as Stakeholder. The custom in London is for the auctioneer to receive and hold the deposit as stakeholder, and he is accountable for it to his vendor. On receipt by him of a letter signed by the purchaser to the effect that the purchase has been completed, the auctioneer is at liberty to hand over the deposit. This is done in the usual way, deductions being made from it for out-of-pocket expenses and commission as agreed, a cheque for the balance being forwarded. It occasionally happens that an auctioneer is made the party to an action at law by either vendor or purchaser to recover the deposit. Inasmuch as an auctioneer must not part with the money until he has the authority of the purchaser that the purchase has been completed, his position under circumstances such as these is somewhat disagreeable; and he would be well advised in getting rid of his liability by paying the deposit into court. His action in this case will not debar him from recovering his commission and expenses as agreed.

There are one or two points which are likely to arise during the course of a sale by auction which may here be noted. During the opening of a sale it may happen that any one of the audience may make use of some deprecatory remarks in the hope of stifling competition. The best way for the auctioneer to act is to inform his questioner that he is selling as per particulars, and if the person making the interruption has any doubt as to the genuineness of the property his obvious course is to refrain from bidding altogether.

With regard to disputed bids, it has been held that the auctioneer is entitled to decision, although the best course is to offer the lot again at the last undisputed bidding.

Sales by Order of Chancery. We now have to consider sales by order of the Court of Chancery. The instructions in these cases come through the solicitor acting in the matter, and the auctioneer, as a rule, is nominated to the judge by the solicitor for the successful party to the action. When an auctioneer is nominated he must provide two testimonials from men of standing as to his ability and integrity, and must also procure a security bond in the amount of the money which is likely to pass through his hands. He proceeds with the sale in the ordinary way, the bills announcing the sale being headed, "In the High Court of ——. —— Division. By Order of Mr. Justice ——." Underneath the auctioneer's name, which in this case must be printed in full (although he may add afterwards "of the firm of Messrs. So-and-So"), appear the words "the person appointed by the judge in the action." On the sale day the procedure is as before, with the difference that the auctioneer is provided with the particulars of his reserve price in a sealed envelope, which he receives from the Court, and which are thus designated his "sealed instructions." After ascertaining that he has received the highest obtainable bid, the auctioneer requests the last bidder to come forward, and, without using his hammer, he opens his sealed instructions, announces the property as sold or not, as the case may be, and should then, if sold, close the deal by hammering it at the last bid. A special form of contract, in addition to the ordinary form, properly executed in two parts, is provided, which the purchaser must sign; and the deposit is handed to the solicitor, he having the original signed contract, the auctioneer retaining a copy. Sales by order of the Court are not so remunerative from the point of view of commission as may be supposed, for the remuneration is sometimes cut down by half and three-quarters of the proper scale, it being possibly the opinion that the kudos gained ought to be considered as sufficient solatium.

Rendering Accounts. In rendering accounts, it need scarcely be added, the auctioneer must not be a party to the making of secret commissions obtained through giving orders to a particular firm of printers or advertising agents. The law on this point is stringent, and an auctioneer will be liable to make good to his principal any sums obtained in this way. Nor must he receive commissions from the purchaser without the vendor's knowledge and approval. If he should do so, however, he is liable, not only to pay over any such sum obtained in this way, but also to repay his proper commission obtained on the sale, and may even suffer prosecution by the Corrupt Practices Act, 1907.

We append below a scale of remuneration.

For the Sale by Auction of Freehold and Copyhold Properties or of Leaseholds Held at Ground Rents

On the first £100	5 per cent (in no cases less than £5).
From £100 to £5,000	5 per cent. on the first £100, and $2\frac{1}{2}$ per cent. on the remainder.
Above £5,000	$2\frac{1}{2}$ per cent. on the first £5,000, $1\frac{1}{2}$ per cent. from £5,000 to £10,000, and 1 per cent. upon the remainder. And in each case where fixtures, timber, tenant-right, stock, or other effects are included in the sale, the amount agreed to be paid, if without valuation, will be added to the sum obtained for the property, and commission charged upon the gross amount.

This scale is generally recognised throughout the profession.

Continued

FISHERIES

The Vast Extent of British Fisheries. Steamers and Smacks. Methods of Capture. Nets and Lines Motor Fishing Craft

Continued from page 4848

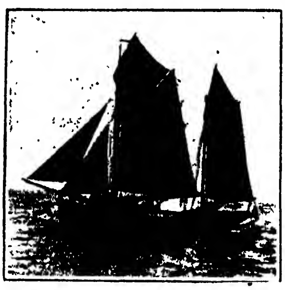
By Dr. J. TRAVIS JENKINS

FEW people—even those who are engaged in one or other of its numerous branches—have any adequate idea of the enormous proportions of the British fishing industry. The not infrequent reports of casualties to fishing vessels which are met with in the columns of the daily Press furnish the reader with some idea of the dangers incidental to a calling at all times difficult and hazardous, success in which is only granted to the active and bold, and mistakes in which result too often in a speedy death.

1. TRAWLING FOR SHRIMPS FROM A CART

Vast Extent of British Fisheries. At the present moment there are over 27,000 vessels engaged in fishing from the various ports in the British Isles. These vessels are manned by not less than 100,000 fishermen, and in the course of twelve months they land nearly 1,000,000 tons of fish, worth to the fishermen about £10,000,000. By the time this fish has reached the consumer its value will be considerably enhanced, the exact amount paid by the consumer being probably not less than £100,000 per day. The value of the ten most important fishes in the year 1905 is appended:

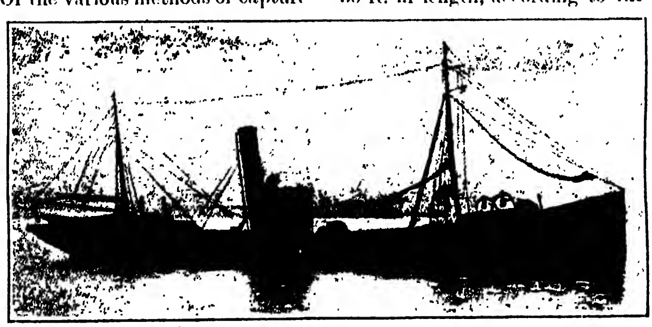
Herring	£2,629,348
Haddock	1,867,073
Cod	1,187,403
Plaice	1,095,416
Soles	485,718
Mackerel..	437,270
Hake	350,147
Turbot	342,525
Halibut	280,574
Skates and Rays	217,152



2. FIRST-CLASS DEEP-SEA SAILING TRAWLER
(The beam trawl is on deck)

For the purpose of fishery statistics a distinction is drawn between *wet* fish and *shell* fish, the former being fishes proper, the latter including oysters, mussels, cockles, crabs, shrimps, and lobsters.

Trawling. Of the various methods of capture in vogue at the present day, undoubtedly the most important is trawling. Trawling is carried on from both steam and sailing vessels, the latter being divided into two classes—the first class consisting of vessels of upwards of 15 tons [2], the second class of vessels below that tonnage. The most remarkable feature in the rise of the trawling industry is the rapid growth both in numbers and in size of the steam trawler, and the consequent supplanting of the smack. In 1905 there were 1,173 steam trawlers and 904 sailing trawlers of the first class exclusively engaged in trawling from ports in England and Wales.



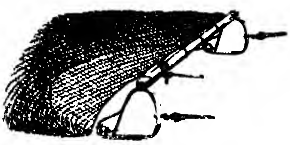
3. FLEETWOOD STEAM TRAWLER

Steamer versus Smack. The slow method of the cutter is rapidly giving way to the scientific methods of the steam trawler [3]. But since the tendency of modern legislation is to exclude the steam trawler more and more from the inshore waters, there always will be room for the inshore fisherman, who, however, in order to be able to compete in the market with his wealthier and more powerful rival, will have to adopt newer methods. Already on the Continent fishing boats which formerly relied on the wind for their propulsion are being extensively fitted up with motors, and the attention of the English smacksman is earnestly directed to the description of motor fishing boats which we give below.

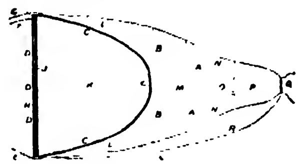
Trawl Nets. Modern trawl nets are of two main types, the *beam trawl* and the *otter trawl*, the former being almost exclusively used in sailing vessels, the latter in steamers. Both nets are constructed and fished with the same object — they sweep along the ground, and consequently are only adapted for catching those fish which live on or near the bottom. Such fish as soles, dabs, plaice, haddock, and cod are captured by this method of fishing, other methods being employed for herring, mackerel, and similar species which live near the surface. The net attached to the *beam*—which consists of wood, and averages from 20 to 50 ft. in length, according to the size of the vessel using it—is shaped somewhat like a flattened cone [5]. The beam is affixed at each end to a triangular iron frame—the *trawl head*—these frames being dragged along the bottom with the beam attached to the apex of the triangle so that when in action the beam is raised a few feet above the ground and forms the upper boundary of the mouth of the trawl [4]. The lower margin of the trawl

mouth consists of a heavy rope, the *foot-rope*, considerably longer than the beam, so that it curves backwards behind the beam, and, unlike it, is in contact with the ground. The terminal portion of the net is known as the *cod-end*, and is fastened by a rope which can be detached when the trawl is hoisted on deck, the catch being thus easily liberated. At intervals in the net there are net-like contrivances known as *pockets*, which, in effect, minimise the efforts of fish to escape through the mouth of the net. The trawl is towed along by two ropes, the *bridles*, which are attached to the trawl-heads, and united at the *shackle* to form a single towing rope—the *trawl-warp*.

Improvement of the Trawl. About the year 1893 a modification of the trawl was introduced, and this may briefly be described as a supersession of the *beam* by means of a rope called the *head-line*, the main advantages being a greater length of opening, head-lines of over a hundred feet in length being common. At either end of the *foot-rope* is attached a heavy wooden door-like



4. TRAWL HEADS, BEAM, MOUTH OF NET, ETC.
Showing how the bridles are attached

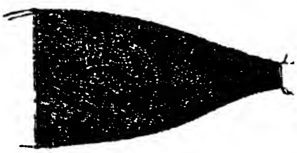


5. DIAGRAM OF BEAM TRAWL
a. Where the net is sewn together to form pockets *b.* Where the square joins the baitings *c.* Foot-rope *d.* Grommets *e.* Forward bridle *f.* Dandy bridle *g.* After bridle *h.* Beam *j.* Head-line *k.* Square of net *l.* Wings *m.* Baiting on top, belly underneath *n.* Pocket *o.* Flapper *p.* Cod-end *q.* Poke-line *r.* Cod-line

board, the *otter-board*, and to these boards the *trawl-ropes* are attached in such a manner that the former are dragged along the bottom on one of their long edges, the surface of the board being inclined at an angle to the direction in which the net is being dragged, so that the mouth of the net is kept open. There are two warps used with the otter-trawl, instead of one only as in the beam-trawl. When the trawl is shot and on the bottom, the steamer tows it along slowly, a fair average speed being about three miles an hour. The pressure of water is exercised in such a manner that the boards are forced upwards and apart, the mouth of the net being thus kept in a distended position. The *head-line*, which is a few feet from the bottom, passes over the fish before they are disturbed by the *foot-rope*, which curves backwards as described above. The fish when disturbed swim upwards and strike the netting of the upper part of the net, which is now well above them, and the pressure of the water forces them into the net towards the *cod-end*. The lower part of the net, which runs along the bottom, is subject to considerable wear and tear, and is strengthened by apron-like pieces of netting, which save the net proper [6].

The Seine. Intermediate between the *trawl* and the *drift-net* described below is the *seine*, which resembles the trawl in its being dragged through the water, and the drift-net in that it is a vertical wall of netting. It is almost exclusively employed in inshore fishing, and for such fish as herring, mackerel, pilchards, bass, and mullet. The seine consists of a vertical wall of netting, to the upper part of which corks or *floats* are attached, to the lower part weights or *sinkers*. It is used from two boats or from the shore with one boat. In either case the net is piled up in the stern of the boat which moves. In this way an area is surrounded by the net, which is pulled in gradually towards the shore.

Drift Netting. While *trawling* and *lining* are the methods employed for the capture of bottom living fish, for those fish which live in intermediate depths to the surface other methods have to be used. Such a method is the *drift-net*, extensively practised in the capture of herring, mackerel, and pilchards. A drift-net is usually composed of pieces of net measuring 10 yards in depth and 30 fathoms in length. From a large drifter the *train* or *fleet* of nets may be a couple of miles or more in length. The whole net hangs vertically in the water, forming a wall of network against which the fish impinge. The upper surface of the net is attached to a rope supported by cork floats, the whole apparatus being so arranged that it can be fished at any required depth, and when fishing it drifts with the tide. Nets of different-sized mesh are used according to the fish which it is desired to capture, the usual size for mackerel being 1¼ in. from knot to knot, for herring 1 in., and for pilchards ¾ in. When a fish strikes against the net its head passes through, but owing to the increasing size of its body the fish is fixed in the mesh.



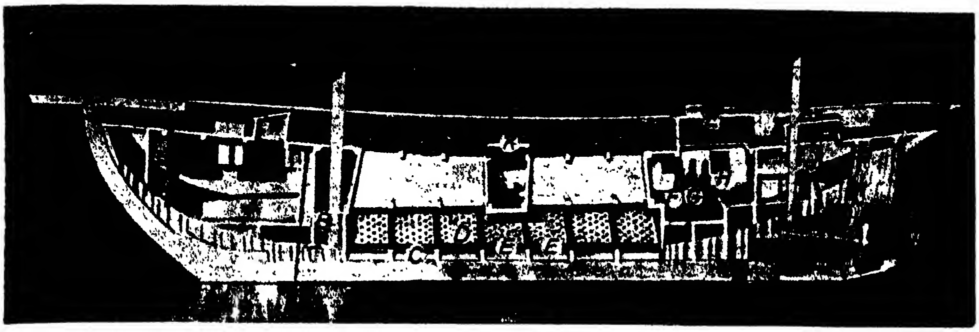
6. BEAM TRAWL WITH COD-END UNLOOSED

Even in this method of fishing we find steamers extensively employed. In 1904 there were 75 steam drifters engaged in Scotland alone, in addition to thousands of sailing boats.

Drift nets were originally made of hemp in Ireland, and in the Isle of Man of flax, but at the present day they are chiefly made of cotton, the greater lightness of which has enabled fishermen to extend the length of their nets. The introduction of an auxiliary engine for hauling nets has also enabled fishermen to extend the length.

The Trammel Net. Except for the fact that it is fixed, the *trammel* might well be regarded as an offshoot of the drift net. It consists of three vertical nets fastened together at the top, bottom, and ends. The middle net *hangs loose*, and is of small mesh. The outer nets, one on either surface, have wide meshes from three to six inches or more from knot to knot, and are of coarser thread than the inner net. The fish swims along until it strikes the outer net, then it darts forward suddenly, pushes against the central net, and carries a portion of it through the large meshed net on the other side. The fish is then safely trapped in a sort of pocket, or, technically, is *trammelled*.

The Stake Net. The *stake net* is a vertical wall of netting supported by stakes, and is a fixed apparatus employed in estuaries. It is a very ancient method of fishing, and a very destructive one, consequently its use is restricted as far as possible. As a general rule these nets may not now be set right across a stream or channel, and there are other regulations, which vary in different localities, as to the size of mesh, and the total length of the net. The varieties of stake net are legion, but it is in the United States that they have reached their maximum development. In this country the nets are usually a simple wall, with or without a trap-like arrangement at the fishing end. They are set at right angles to the direction



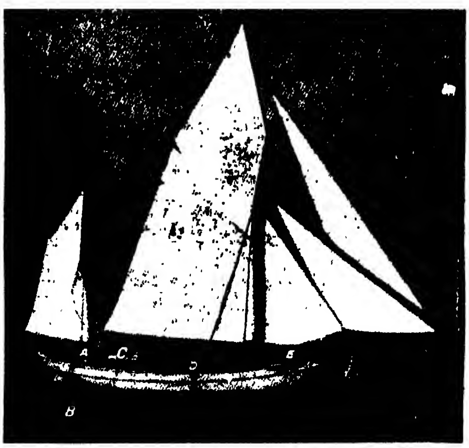
7. LONGITUDINAL SECTION OF DEEP-SEA CUTTER "ELLEN"

a. Forecastle *b.* Space for salted fish *c.* Ballast *a.* Well *e.* Grating *f.* Motor of 4-h.p. *g.* Motor of 16-h.p. *h.* Motor-room *j.* aptain's cabin *k* Hatchway *l.* Roof of motor-room

of the tide, and may be calculated at certain seasons of the year to yield the maximum of result with the minimum of effort.

Line Fishing. A large quantity of deep sea fish is still caught by *lining*, and this is more particularly the case in Scotland, where, in 1905, no less than 164 steamers and 4,593 sailing vessels were engaged in this branch of fishing, their catch during the year amounting to 735,654 cwt., and its value being £348,610. A line as used on a steam vessel is usually several miles in length, and at intervals of about 6 ft. is provided with pieces of line, the *snoods*, to which baited hooks are attached. The position of the line is marked by buoys. The hooks are usually baited with mussels, whelks or herring, and the lines are shot in the evening, and fished in the morning. The line can be used on rocky ground where trawling is obviously impossible.

Fishing for Crustacea. In addition to the various methods of fishing for *wet* fish, which have been described, there is an extensive fishery for various *crustacea* such as shrimps, prawns, lobsters and crabs, the value of which to the fishermen for England and Wales alone is certainly not less than £200,000 a year. Shrimps are fished for by *trawl nets*, and also by *hand nets*. The former are modifications of the beam trawl adapted for catching shrimps, the *mesh* being three-eighths of an inch from knot to knot, and the *beam* not more than 25 ft. in length. The *shank net* is very similar, the mouth of the net being, however, kept open by means of an oblong frame of iron or wood. This net is used precisely like a trawl, being dragged along the bottom, and while so dragged the frame is kept in a vertical position, the longer axis being horizontal. Such nets are frequently used from carts which are driven along in a few inches of water at low tide [1]. In similar localities, a hand net, known as a *push* or *power net*, is used. This varies in different parts of the coast; generally speaking, it consists of a triangular net attached to a framework, the whole apparatus being fixed at the end of a long pole. This net is pushed in front of the shrimper in shallow water, at low tide, and is hence locally known as a *shore net*. On his back, the shrimper carries a large basket for the reception of his shrimps. Crabs and lobsters are mainly fished for by baited pots, in reality basket-like arrangements, or traps, which afford facilities for the ingress but bar the egress of the crustacean. These pots and baskets are lowered to the bottom, often in fairly deep water on rocky ground, their position being indicated by buoys. At the end of several hours the fishermen revisit the grounds, examine the pots, remove their lobsters or crabs, and finally re-bait their pots with stinking fish.



8. DANISH DEEP-SEA CUTTER "ELLEN"

a. Entrance to captain's cabin *b.* Auxiliary screw *c.* Roof of motor-room *d.* Motor boat on deck *e.* Entrance to forecastle

Fishing in the Future. A remarkable change has taken place in the fishing industry during the last twenty years. Previous to the advent of the steam fishing boat the smaller fishing villages were relatively far more important than they are at the present time, and the inshore fisherman who followed different classes of fishing at different seasons of the year—trawling, drift-netting, lining, and shrimping—is fast being replaced by the steam fisherman, who is a specialist pure and simple.

The bulk of sea-fish is landed at half a dozen large ports, such as Grimsby, Hull, Aberdeen, Milford, Fleetwood, and Liverpool, where access to the quays and wharves is available at all stages of the tide. The fish landed is usually sold at once by auction, and then forwarded to the markets at the large inland towns. The sailing smack owned partly or entirely by the man who sailed her is slowly but surely decreasing in numbers, and is being supplanted by the steamer, owned almost invariably by persons whose interest in the fisheries is mainly dependent upon their dividends. The fishermen are paid servants, or in some instances are paid by a share of the gross profits, the skipper and mate usually being paid by shares, the rest of a crew by a weekly wage. Already there are whispers of "rings" of buyers and dealers in fish, and who can say what the future of the inshore fisherman is to be?

Conditions of Success in the Future. The self-reliant and independent fisherman will, therefore, take heed of the future: only by embracing as far as may be practicable newer methods of fishing will he be able to compete successfully with his formidable rivals. The adoption of means for keeping his catch in good condition, and for securing its rapid transit to the market, the introduction of labour-saving devices for manipulating his gear, and, above all, the question of auxiliary propulsive methods to assist the uncertain winds, are all subjects which will imperatively demand his immediate and earnest attention.

The regulations for the protection of the inshore fishing grounds are for the most part based on sound reasoning, and may be said to have been productive of good effect, though their introduction has not always been welcomed by the individuals whom they were designed to benefit.

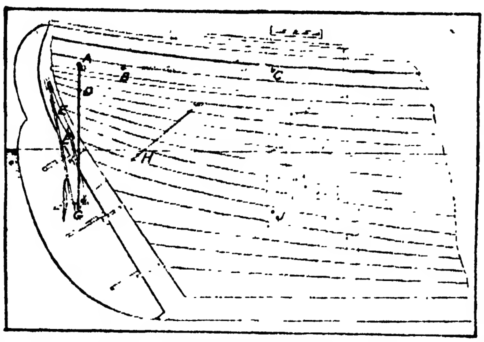
Motor Fishing Craft. The possibility of the application of motor power to the sea-fishing industry has for some time been recognised on the Continent, notably in Denmark and Germany, and auxiliary petrol motors have been applied to various classes of fishing smacks, and especially to deep-sea cutters of similar build, to the first-class English sailing trawler, to herring, and to open line-fishing boats. This application must at present be regarded as in its experimental stages.

9. DANISH DEEP-SEA CUTTER WITH MOTOR AND LOOSELY SUSPENDED PROPELLER

In the Danish deep-sea liners [8] we have an auxiliary screw permanently fitted up, in contradistinction to the screw which is lowered over the stern and hauled in at pleasure. The cutter Ellen with the letter and number K2, Copenhagen 2, is oak built, and contains a well in which the fish are kept alive. She has a crew of six men, and fishes principally in the Kattegat, Skagerack, and the North Sea, and also off the Icelandic coast. She fishes winter and summer alike. On deck she carries a motor boat 19 ft. long, with a motor of $1\frac{1}{2}$-horse power. In longitudinal section [7] are seen the internal arrangements of the cutter. This craft possesses two petrol motors, one being a two-cylinder 16-horse power machine which drives the screw, and the other of 4-horse power, which is used for hauling in the anchor and fishing line.

A cutter such as this would be 54 tons gross, and about 60 ft. long. The cost of building at Frederikshavn would be £1,620, inclusive of internal equipment.

Smaller Type of Danish Motor Cutter. A second description of motor which is used abroad in the sea fishing industry is illustrated in **9** and **10**, which picture a Danish cutter somewhat smaller than the preceding one. Here we have an example of a deep-sea cutter fitted with a loose suspended screw. Fig. **9** shows the stern of the cutter with the screw in position. Fig. **10** is a section showing the way this screw is attached to the motor. An axle or shaft running along the upper deck connects the motor with a toothed wheel which projects over the stern of the cutter. Over this toothed wheel runs an endless chain, by means of which the rotation of the screw is set up. The screw-axle is attached to the hull by means of two movable iron rods, and the arrangement is such that the whole can be removed or replaced at pleasure. In stormy weather the screw and frame would be removed because it is easily washed away. In calm weather the screw is placed in position, and in a cutter of from 20 to 40 tons a motor of 6-horse power would give a speed of from two to three knots, which is quite sufficient for trawling purposes. Anyone who has been becalmed for two or three days at sea in a deep-sea smack will realise the enormous advantage of being able to travel even at this snail's pace. Figs. **7** to **10** have been reproduced from photographs of models in the Altona Museum and published in the "Mitteilungen des Deutschen Seefischerei Vereins."



10. DIAGRAM OF DANISH DEEP-SEA CUTTER WITH SUSPENDED PROPELLER

a. Toothed wheel *b.* Shaft *c.* Pulley *d.* Endless chain *e.* Movable iron bars *f.* Propeller *g.* Screw-axle *h.* Removable iron rod *j.* Driving wheel

Open Danish Motor Boats. In addition, open petrol-motor fishing boats are used in the Baltic. These open boats possess a mast with two sails. The mast can be lowered at pleasure. These boats are about $23\frac{1}{2}$ ft. long and have a crew of four men. The motor is of 2·5 h.-p. The price of such a boat, with motor, sails, anchor, and, in fact, with complete equipment, would be about £118.

All the boats described fish principally or entirely with long lines to which a large number of hooks are attached, and the motor proves of great service in hauling in these lines.

Continued

CYCLOPÆDIA OF SHOPKEEPING

SCIENTIFIC INSTRUMENT DEALERS. The Sale of Chemical, Electrical, Radiographic, Optical, Meteorological, and Physical Apparatus

SEEDSMEN. Training. Starting Business. Grasses, Flower Seeds and Bulbs. Packet Trade and Side Lines. Profits

SEWING MACHINE DEALERS. A Profitable Side Line. A Small Stock. Prices and Profits. Selling and Repairing

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SCIENTIFIC INSTRUMENT DEALERS

The dealer in scientific instruments can scarcely be said to exist as a distinct trader covering all the branches which will be dealt with in this article. The departments are usually worked with other businesses. The chemical apparatus section, for example, is often found as part of a chemist's business, and the sale of the articles here classed as *optical goods* is frequently embodied with the sale of spectacles. It has, therefore, been thought best to tell under separate sections the chief facts connected with each class of scientific apparatus so as to assist those who would desire to branch out in new directions. At the same time there is nothing except the lack of suitable openings to prevent anyone devoting a business to the whole of the branches dealt with in the following paragraphs. The profits on these goods are roughly 25 to 33⅓ per cent., which is little enough when the liability to breakage is considered.

Chemical Apparatus. With the popularisation of science and the multiplication of science schools the demand for chemical apparatus has increased of late years. Nothing fires the ambition of a schoolboy more than to see chemical experiments performed, and for this reason a tradesman with scientific leanings, whose premises are in proximity to a public school, should certainly not neglect to cater for the schoolboy bent on making oxygen or performing at home other simple experiments seen in the lecture-room. At some colleges the student is required to provide a certain amount of apparatus and reagents, the larger apparatus and cheaper reagents being found by the educational establishment; and again it is a laudable thing that at certain schools the prizes in chemistry classes take the form of chemical cabinets. Statham's chemical cabinets are sold at prices ranging from 2s. 6d. to one guinea; but special sets of apparatus and chemicals adapted for particular textbooks are readily assembled. The following are some of the most frequently sold pieces of apparatus: small mortars and pestles, in glass, Berlin porcelain, Wedgwood or agate, varying in price from 4d. for a porcelain mortar of 2½ in. diameter to 70s. for a moderate sized agate mortar. A few glass mortars is sufficient for a small trader to stock. Bunsen burners sell at 1s. each, larger and better ones for 1s. 9d. Spirit lamps, 1-oz. size, sell at 8d.; 4-oz size at 1s. Wire gauze is best sold in 6 in. squares at 3d. each (iron); 1s. each (nickel); and 6d. each (copper). A newer variety is that with an asbestos centre, selling at 8d. and 9d. Crucible tongs sell at 1s. each; cork borers at 9d. per set of three; retort stands at 1s. to 5s., according to number and size of rings; metal tripods sell at 1s. to 1s. 6d. each: test-tube stands at from 6d. (for six) to 2s. (for 24 tubes); test-tube brushes sell at 1½d. each: with sponge ends, 2d. each; and the india-rubber variety at 3d. each. Pipe-stem triangles sell at 3d. each or 2s. 6d. a dozen. Flasks sell at 3d. each for 2-oz. size; 4d. for 4-oz. size; 5d. for 6-oz. size; and 9d. for 20-oz. size. Beakers are best sold in sets, the wide form with lips being preferred. A set of 1-oz to 5-oz. sells at 1s. 3d.; 5 oz. to 20-oz. at 2s. the set. Funnels sell at 2d. each (2-in. size); 3d. (3-in.); and 4d. (4-in.); and for these filter papers, cut in circles, are required, selling at 6d., 9d. and 1s. 3d. per 100. Wash bottles sell at 1s. (10-oz.), and 1s. 3d. (20-oz.). Woulff's bottles with two necks sell at 9d. (5-oz.), and 1s. 6d. (15-oz.). Blowpipes in japanned tin sell at 6d.; in brass, at 8d. The most convenient size for test tubes is 5in. by ⅝ in., these selling at two for 1½d. or 8d. a doz., or 5s. 6d. a gross. Nests of six different size tubes are also handy; they sell at 9d. for 6, or 1s. 6d. for a nest of 12. Books of test papers sell at 2d. each all kinds, or 4d. in rolls. A stock of corks and india-rubber stoppers is also needed and reagent bottles varying in size from 1 oz. to 40-oz. It falls to the lot of the dealer in chemical apparatus to fit up benches in schools, these being supplied at a cost of about 42s. per pupil, the benches at this price being in fours. A fume cupboard, needed in every well-appointed laboratory, can be fitted up in good style for £4. Balances for weighing small quantities can be supplied at £3 10s. each, a better instrument costing £10. Weights—in the metric system—are supplied at a cost of from 2s. 6d. to 30s. A large variety of graduated glass apparatus is needed for accurate analytical work, some of which will need to be stocked if the business increases.

Electrical Apparatus. The sale of electrical apparatus is an inviting side-line which may be begun with a small outlay and grow to unlimited proportions. A good show can be made for an outlay of £5, and the goods purchased should be put in the window so as to attract attention. Start with the most simple of saleable electrical apparatus—the bell. These are quick-selling lines, if sold on cards, complete sets of parts for fitting up a bell and battery selling at from 1s. 6d. A complete bell and battery sells at 5s., this including push and wire. The portable bells used by invalids sell at from 10s. 6d. to 15s. each. The sources of electricity, that is the batteries, are various. The Leclanché cell, used in the above electric bell sets, can be sold at 1s. 6d. each. The other well-known batteries are Daniell's (complete, pint size, 4s. 6d.); Grove's (pint size, 4s., platinum extra, about 7s. 6d.); Bunsen's carbon (pint, 3s. 6d.); Smee's (pint, 5s., requires a piece of platinised silver), and bichromate (pint size, 3s. 6d.). After the Leclanché the most popular is the bichromate battery. Dry cells are much in demand, the E. C. C. and Obach cells selling at from 2s. to 6s. each. The Obach cells are distinguished by letters: B, D, M, Q, O, and S., according to the

use to which they are adapted. The smallest are D and S, and are useful for electro-medical purposes. Accumulators cost from 10s. for the pocket variety to £7 for a six-cell seven-plate battery with a capacity of 45 ampere hours. Spare parts of batteries are also needed and insulated copper wire for connections. The latter, cotton covered, costs from 1s. 8d. (S. W. G. 16) to 3s. 6d. per lb. (S. W. G. 28). Small electric light sets sell well at 2s. 6d. when carded in like manner to the electric bell sets. Small electric motors in parts sell at 2s. 6d. (costing 1s. 6d.), while motors ready for use can be bought to sell profitably at 2s. to 15s. These little motors are useful for various purposes, and are sold at prices up to £4 for serious work. In this department magnets are stocked; these cost from 1s. 10d. a dozen (2 in. long) to 90s. a dozen (14 in. long). These are the ordinary horse-shoe magnets, but straight bar magnets are also in request, small ones for toys costing as little as 9s. 9d. per gross. A 12-in. magnet costs 1s. 9d. each; a 6-in. 6d. each. Magneto-electric machines used for medical purposes and for amusement can be sold at from 7s. 6d. (in pine box) to two guineas. The latter is a superior apparatus in mahogany box. Telephones can be bought to sell at as low as 35s. complete. They are easily fitted up and useful for connecting dining-room and kitchen or warehouse and shop.

Radiographic Apparatus. Closely allied to the department just described is the sale of apparatus for radiography or for generating X-rays. Small induction coils are used for obtaining shocks, one to give ½-in. spark selling at 30s. Many boys prefer to make their own coils, and some succeed, but it needs the patience and perseverance of an enthusiast to equal the product of the factory. The minimum equipment needed by the radiographer is a Ruhmkorff induction coil giving at least a 4-in spark. A coil this size costs £10, and owing to improvements of late years, the size of the coil has now been reduced to nearly half of what it used to be. A source of electricity is needed; this can be either the electric supply of the town or accumulators. A four-cell accumulator (8-volt) costs about £3 10s., and can be recharged for 1s. A Tesla transformer can be used in place of the coil; the cost is the same. The Crookes tubes cost from 12s. 6d. in their simplest form to 40s. for some newer forms, which are fitted with water-cooled anodes. The fluorescent screens used in X-ray work are covered with barium platino-cyanide—an expensive chemical—and cost at the rate of £2 2s. for a double-coated screen, 7½ by 10. A few accessories are needed, such as tube holder and connecting wires. The taking of radiographs is a branch of photography in that the plates are developed and printed in the same way, but a camera and lens are not employed.

Optical Apparatus. Under this head is classed goods in which lenses are used, except photographic lenses, which are treated of in the article on photography [see page 4419.] Microscopes in the simplest form—straight body in mahogany box—can be bought to sell at 3s. 6d.; with three-power, divisible objective, 5s. and 6s. The next style is the pillar microscope, which magnifies about thirty times, selling at 8s. 6d., with more powerful instruments, which sell up to 20s. The better class of microscope for the student sells at two guineas, such an instrument having rack and fine adjustment, and ¼-in. objective dividing to ½ in. and 1 in.; the whole being in a cabinet. Better instruments sell at £5; but a microscope for bacteriological work costs £15, and may cost £50 for one of the magnificent productions of Zeiss, of Jena. There are a number of accessories required for the worker with the microscope, such as dissecting scissors (sell at 1s. each), scalpels (1s. each), glass slips (cost 2s. 6d. gross), zoophite troughs (1s. and 1s. 6d. each), microscopic slide cabinets (from 1s. each, holding 12 slides, to 4s. each, holding a gross of slides). Microscope slides sell at from 3d. to 1s. each, the former being for small instruments. There are special lenses made for botanical students, known as Coddington and Stanhope lenses. These sell at 3s. to 4s. each, according to the manner in which they are mounted. The folding triple lenses much favoured by natural history students sell at 2s. 6d., and cost 14s. and 15s. a dozen, according to whether the mount is horn or vulcanite. Linen provers used for counting the threads in cotton and linen cloth—small folding lenses—cost from 5s. a dozen to 35s. a dozen. Watchmakers' eyeglasses cost 4s. to 7s. 6d. Tripod microscopes, known also as gardeners' microscopes, sell at 1s., and cost 9s. a dozen. Toy microscopes can be bought, carded, to sell as low as 6d. each. Reading glasses, favoured by elderly people, sell at 9d. to 10s. A good way to buy these magnifiers is in a set of 13, which costs 35s., a stand for containing these being supplied at 4s.

At the seaside telescopes are saleable, but cheap carded lines can be sold anywhere at prices ranging from 1s. 6d. The better class telescope, achromatic, three-draw, leather covered, sells at 5s. (10 lines) to 15s. (19 lines). A tourist telescope with four draw tubes, which sells at 20s. to 30s., is a popular line. Such an instrument has a sling case for carrying it. Marine telescopes sell at 15s. to 60s., and astronomical telescopes cost from 35s. to £10, selling at 2 guineas to 12 guineas. Binocular telescopes, which are in form like long opera glasses, cost from £3 to £6, a medium size, in case, being obtainable to sell at £4. From binocular telescopes to opera glasses is but a short cut. Opera glasses can be had to sell at 4s. 6d., but these are non-achromatic, and unpleasant for continued use. Achromatic opera glasses (leather-covered, nickel mounts, six lenses) cost about 5s., and sell well at 7s. 6d. Better instruments cost up to 70s. each, but a good saleable line should be stocked which sells at 15s., which is the popular price. There are much more expensive forms of opera glasses, the extra cost being made up of the pearl and gilt exteriors. Field and marine glasses cost from 9s. to 60s., a line selling at a guinea and a half being in demand. The new prism binoculars of Zeiss or Goerz sell at from £5 10s. to £9. This seems a long price, but they are well worth it when the optical qualities are considered. Stereoscopes are not at present so popular as formerly, but they have a steady sale. The cheapest sell at 2s. each, a good line being one selling at 5s. The views for use with these sell at 3d. to 1s. 3d. each. The pedestal stereoscopes fitted with revolving stereoscope and holding 50 slides sell at 30s. to £3. Bacteriological apparatus properly comes in this section; besides a good microscope, various accessories are needed for preparing and staining the various bacteria.

Meteorological Apparatus. Thermometers sell for as low as 6d., but at this price are not very trustworthy. One shilling is a recognised price for a thermometer, and to sell at this price a good boxwood scale, mercury column instrument costing 8s. a dozen is recommended. Bath thermometers have square, wooden frames and a

handle, so that the water of the bath can be stirred. The graduations are also specially indicative of the temperatures of the different baths. Metal frame thermometers are best adapted for outdoor use and in the greenhouse. In the latter position, maximum and minimum thermometers are of greatest use, a good instrument selling at 5s. Mercury thermometers with enclosed scale are also sold for chemical use, while clinical thermometers for taking the temperature of the body are in great demand. These sell at 2s. 6d., 5s., and 7s. 6d., the last-named being lens-fronted and specially sensitive.

Barometers are in two varieties—aneroid and Fitzroy. The cheapest kind of aneroid, $4\frac{1}{2}$-in. dial, sells at 12s. 6d., better kinds in wood outer case selling at 15s. to 20s. Aneroids are also sold mounted with a thermometer at a price to allow them to be sold at 30s. to 60s., but much more money is required to buy some of the elaborate Chippendale patterns, it being in these cases a matter of cabinet-making of the best kind. Fancy forms of aneroids are made for presentation as sporting trophies—usually combined with a clock. Fitzroy and pediment barometers, in which a column of mercury is employed, sell at from 15s. Self-recording barometers, or barographs, in which variations of atmospheric pressure are automatically recorded, cost from £4. Rain gauges sell at from 7s. 6d. to 15s., the former being fitted with a 5-in. japanned tin rain gauge. Other instruments falling in this section are anemometers (for registering wind pressure), sunshine recorders, weather glasses, and hygrometers.

Physical Apparatus. There are a number of apparatus which do not properly fall into any of the foregoing sections, but which are purchased from the dealer in scientific apparatus. Among these may be mentioned water stills, milk testers, hydrometers, alcoholometers, saccharimeters, polarimeters, urinometers, and argentometers; tintometers, nitrometers, photometers, pedometers, micrometers, and viscosimeters; cement testers, flash-point apparatus, air pumps, theodolites, sextants, and compasses. These are mentioned to show the almost unlimited scope of the trader in these goods. Drawing instruments, measuring instruments, mechanical counters, slide rules, gauges and graduated instruments are other classes of instruments which open up a vista of promise to one extending the scope of his business.

SEEDSMEN

In the spring the householder's fancy often turns to thoughts of seeds. This applies more particularly if the householder is a resident of Suburbia, with a garden and grass-plot of his own, however small. And who does not pride himself on his flowers, or who tends with more pathetic care the cabbage, carrot, or potato of his own rearing than the man in the town, who more often than not has been reared in the country? The impetus which the "return to Nature" has given to growing not only the flowers of the field but the produce of the earth, in recent years, has been marked, and Garden Cities are now a vogue. Without taking into account, therefore, the needs of the gardener, the agriculturist, and others who make their livings by the growth of seeds, it will be seen that the demand for the staples of the seedsman are more or less universal. There are openings all over the country for good, practical seedsmen who know their business thoroughly; and the seed and allied trades appeal to the healthful-minded young person, not only from a hygienic but also from a pecuniary point of view. There is money in it and a crying need for well-trained men. The ironmonger and the chemist often have seeds as a side-line, but the selling of seeds is the true business of neither, and the man with the sure inside knowledge always has the pull.

The Importance of Apprenticeship. It is extremely important, therefore, that the youth who intends to be a seedsman should be well trained. The decline of the apprenticeship system has of late years adversely affected this as well as other trades. Nowadays, many of the men who go into the business are but imperfectly acquainted with the rudiments of the work. They have served no regular apprenticeship: in fact, the hurry and scurry of modern competition renders it increasingly difficult for employers with the necessary facilities to spend time in the training of apprentices. But the importance, from the point of view of future success, of serving a proper apprenticeship cannnot be unduly emphasised. The lad who in some way has been connected with the country, or whose parents are engaged in agricultural or horticultural pursuits, often makes the best seedsman. But a country upbringing is by no means indispensable, for many of the successful seedsmen of to-day are town-bred. The essential thing is to serve a regular apprenticeship of four or five years with a good, practical seedsman who has an all-round general business. Indentured apprenticeships are a thing of the past, and more is the pity; but there are still many places where the business can be learned thoroughly and where the boy will be paid a wage of 4s., 5s., 6s., 7s., and 8s. per week, during the period of his tutelage.

The Training and After. Having selected a good medium-sized business as a training-ground, the youth will find that—should the employer also be a nurseryman—he will spend most of the first two years in the nursery, learning the mysteries of potting, transplanting, grafting, and so on. He will thus become familiar with the names and characters of plants, and any leisure he may have can be advantageously devoted to the study of trade catalogues, by means of which he will become acquainted with the names and kinds of seeds, flowers, bulbs, etc. At the end of two years he will probably be taken into the shop, where, in the busy season, he will assist in packing and delivering the goods sold, and will gain a knowledge of the importance of chemical manures and the innumerable horticultural sundries sold as side-lines. In the course of the next three years (we are assuming a five-years' apprenticeship) he will gradually rise to the position of counterman, assisting generally in the finer departments of the business. He will also learn business methods, and in a medium-sized business, such as forms the ideal apprentice-ground, it is customary to give the apprentice a period at the books. His apprenticeship over, the youth who has applied himself to the acquisition of knowledge will have no difficulty in getting a situation as assistant in another business at once, at a wage of from 20s. to 25s. per week. The supply of good assistants is never greater than the demand in the seed trade, for there are so many of the untrained, or only partially trained kind about. This is largely owing, as before indicated, to the gradual disuse of the apprenticeship system, so that the thoroughly trained man need never be in want of a situation, and may earn anything from 20s. to £2 a week, according to his capability and energy.

Launching Out. An experienced seedsman has laid down the dictum that it is unwise to start in the seed business on one's own account until one has had an experience of from ten to fifteen years. Probably the ambitious young man will chafe at the idea of waiting ten years after apprenticeship before trying his luck, especially if he be possessed of £100 or £200. A partnership in a fairly large business, where the partners can superintend different departments, may be considered, especially where there are possibilities of considerable development. But we shall assume that the young, and now experienced, seedsman resolves to start out " on his own." Of course, he may find that some particular part of the business suits him best, and in that line—agricultural mainly, horticultural mostly, or the bulb trade entirely—he may specialise. But the usual plan is to begin a business of a general character and gauge the necessities of the locality before specialism is attempted. With a capital of, say £150, a small shop would be selected in a good business neighbourhood. If in a country town the high street, or market place should be the scene of operations, for there the farmers and other country people usually foregather. If in a suburb the shop may be a very tiny one with, perhaps, a piece of nursery ground attached. The fittings in a medium-sized shop would not cost more than £20 to £30. The most expensive item is the drawers for seeds, of which fifty would probably be required; but these may often be bought second-hand in sale-rooms or elsewhere, the rejected fittings of some grocer or chemist. A few shelves round the walls, a counter, two sets of scales (one small for the tiny seeds, the other for the heavier seeds), a weighing machine for potatoes, manures, etc., one or two scoops, and a number of wooden bins would complete the fittings necessary.

Stocking. It is quite unnecessary, nowadays, for the beginner to lay in a large stock of any class of goods. He would merely order a small supply of each commodity for a show, trying to find out as well as he could the class of goods most in demand in the neighbourhood. There are many large seed-growers and merchants, like Sutton & Sons, of Reading, ready to supply him, and almost anything he may require can be procured within twenty-four hours. But one principle should direct his purchases all through his career. He should be careful to select for his stocks only the finest seeds, bulbs, or what not, that he can buy. His experience will have taught him how to judge the goods and the reputable houses to buy from. Cheapness for cheapness' sake should be avoided at all hazards. Bearing this in mind he would expend from £20 to £30 in laying in, in ¼-bushel and ½-bushel quantities, quick-selling seeds like beans (broad bean, kidney bean and runner bean), peas, etc., selecting the varieties that are popular in the district. Then there are vegetable seeds like beet, broccoli, brussels sprouts, cabbage, carrots, leeks, onions, lettuces, parsnip, mustard and cress, parsley, radish, spinach, cauliflower, and celery, to be ordered in from ¼-lb. to 1-lb. quantities. Other vegetable seeds like endive, chervil, cucumber, melon, vegetable marrow, tomato, etc., would be wanted in ½-oz. or 1-oz. quantities, according to their relative value and popularity. Sweet and pot herb seeds like anise, balm, basil, borage, caraway, fennel, horehound, hyssop, lavender, marigold, marjoram, rosemary, rue sage, savory, thyme, and wormwood, would likewise be stocked in ounces or smaller quantities. In beans, peas, cabbage, onions, turnips, etc., the varieties are so numerous and the idiosyncrasies of neighbourhoods in the way of likes and dislikes so dissimilar, that it would be impossible, even if it were wise, to advise what kind to buy. The beginner would probably have one or two kinds of seed potatoes—Early Champions, British Queens, Up-to-Dates, or some others, to which he would pin his faith. One or two varieties of these would be held in stock.

Flower Seeds. This is an important department to the seedsman catering for Suburbia or for towns of any size. It behoves him, therefore, to secure in ½-lb. to 1-lb. lots the most popular hardy annuals, like convolvulus, candytuft, lupin, mignonette, nasturtium, stock, hollyhock, carnation, sweet pea, Virginian stock, wallflower (two or three varieties), sweet-william and sunflower. In smaller quantities order alyssum, Bartonia aurea, Calandrinia speciosa, Chrysanthemum tricolor, Collinsia bicolor and C. alba, ersymium, phlox, Eschscholtzia Californica, scabious, Eutoca viscida, Gilia tricolor, godetia, larkspur, Linum grandiflorum, love-lies-bleeding, Malope grandiflora, Mathola bicornis, Nigella Damascena, Nicotiana, Nemophila insignis, prince's feather, Saponaria, Venus' looking-glass, Viscaria osculata, and Whitlavia grandiflora. In this department the varieties of sweet pea are important, that flower being at the moment extremely fashionable, and when one thinks that in some wholesale catalogues there are from 50 to 80 different varieties named, the magnitude of the business will be understood. It may pay the young seedsman to specialise in sweet peas, chrysanthemums, or others, should he be located in a "flowery" neighbourhood; otherwise his speciality may be in seed potatoes or a particularly fruitful brand of onions.

Sundries. After these several necessary horticultural sundries must be considered. There are small stocks of chemical manures for lawns, plants, and flower-beds to be thought of, not to speak of weed-killers and insecticides. In connection with the sale of the two articles last named the seedsman should be careful to see that the weed-killers or insecticides he sells do not contain a scheduled poison, such as arsenic, strychnine, or nicotine, otherwise he is liable to prosecution under the Pharmacy Acts. Besides being an agent for the chemical manures used on a large scale by the farmer, he would probably find it advantageous to be an agent for nursery stock. Then the sale of garden tools and garden requisites, such as fruit-nets, lawn sand, budding-knives, axes, hoes, rakes, scythes, spades, scissors, trowels, syringes, watering-cans, flower-pots, seed-pans, lawn-mowers, and so forth, is looked upon as an adjunct to the seedsman's business, and £15 at least would have to be expended in such things. In an agricultural community the sale of agricultural implements is often developed into an important side line, for the ironmonger in such districts usually sells seeds. The alert seedsman will not fail to take advantage of the money-spending that goes on so freely at Christmas and New Year. Recently smart men have made quite a profitable feature of Christmas and New Year gifts in the shape of fancy white ware filled artistically with flowering bulbs, such as tulips, hyacinths, and lilies of the valley, and ferns (retailing at from 1s. to 10s. 6d. each), baskets filled with growing plants and flowering bulbs (2s. 6d. to 15s. each), bowls filled with ferns and bulbs (1s., 1s. 6d., and 2s. 6d. each), palms, ferns, aspidistras, araucarias, solanums, heaths and marguerites (from 3d. to

10s. 6d. each). There is also considerable trade to be done at this season of the year in Christmas trees, holly with berry, mistletoe, and evergreens for house and church decorations. All these show at least a 25 per cent. profit on the return, and give a filip to trade.

Agricultural Seeds. If the business done is mainly agricultural, some of the foregoing may be curtailed, and larger stocks laid in of farm seeds. There are many varieties of clovers (red, white, cowgrass, yellow, etc.), rye grasses, natural grasses, swede turnips, yellow turnips, white turnips, mangel wurzels, tares, rape, linseed, and seed potatoes, which farmer customers will demand. Then lawn-grass seeds are much in demand (in towns particularly).

The Bulb Trade. The sale of bulbs and bulbous roots is quite a special trade, and many successful businesses are built up in large towns or busy neighbourhoods on bulbs alone. The more common bulbs may be stocked in ¼-dozen or ½-dozen quantities by the general seedsman, but it is only by making a feature of this branch that a large trade can be done. However, if the seedsman has a preference for bulbs, it is a branch worth cultivating, provided he can get at the proper growers and obtain original and healthy plants, and a selection sufficiently varied. The bulbs and bulbous flower roots usually in demand are hyacinths, tulips, crocuses, jonquils, daffodils, narcissuses, irises, and liliums for conservatories or for window decoration. For growing in the open ground there are, besides those mentioned, gladioluses, anemones, ranunculuses, aconites, snowdrops, and begonias. The cost of these is not great, but the varieties are so numerous that it will be found very difficult, at first at least, to keep anything like an adequate stock with the small capital indicated.

Packing and Packet Trade. Of recent years the trade in packet seeds has increased largely. This has not been altogether a good thing for the seedsman, for many small shopkeepers have made it a practice to sell flower-seeds, particularly in penny packets. Such outside sellers not only diminish the sales of the seedsman, but often the packet seeds of these irresponsible sellers are held in stock season after season, and by the time they are sold they are useless. But at least one man in England has built up a large business in packeted seeds (flowers and vegetables), the main part of the business being done by post. A regular seedsman, however, would not buy packet seeds. He would buy reputable seeds in bulk, send to a horticultural printer like Messrs. Blake & Mackenzie, of Liverpool, for pockets or coloured envelopes of different sizes, and weigh and pack his own seeds. The printers named have specialised in horticultural printing for over half a century. They introduced the flower and vegetable seed packets now familiar to everyone. Before then the seedsmen used to pack up their seeds in folded papers, and use cuttings of parchment for "directions." Nowadays lithographs in natural colours of the flowers and seeds are given on the packets, and the directions for use are printed on the back, along with the name of the plant and its characteristics. Seed pockets (plain), in sizes of from ½-oz. to 6-oz. capacity, cost from 3s. to 7s. 6d. per 1,000. The coloured envelopes are a little more expensive. They may be had in all sizes, for all kinds of seeds, and they are very attractive. Seeds for quick sale are usually packed in 1d., 2d., 3d., 6d., 1s., 1s. 6d., and 2s. 6d. sizes, and they return a very good profit. Seed bags holding from ½ lb. to 7 lb. are also needed. These are of good strong paper, and cost perhaps about 35s. per cwt. The pockets, bags, luggage labels, and miscellaneous stationery have, of course, the name and address of the vendor printed on them. This is an advertisement every time a sale is made, but, in addition, it is advisable to issue a small catalogue when opening shop. There are some fine samples of stock catalogues, bearing name and address on the cover, to be obtained from horticultural printers at a cost of about £5 per 1,000, or even less. There are many varieties of resplendent catalogues devoted entirely to the bulb trade.

Business Bringing and Profits. The judicious distribution of a neat and effective catalogue is one of the first things to be done in securing a connection. But, besides that, the man who means to make his way must go and look for orders. In the off season, during the summer, he should be cultivating the acquaintance of gardeners, farmers, amateurs, growers of fruits, flowers or vegetables, stewards of landed property, and other likely customers. In an agricultural district he will find that attendance at the markets is imperative, and a good deal of hard work and persistent canvassing has to be done before anything like a good business is established. With regard to remuneration for his work, the profit all round should average not less than 30 to 40 per cent. on the turnover. The biggest profits are on the sales of the smaller seeds, and if only a large and quick turnover in made-up packets can be secured, the gross profits will rise to the neighbourhood of 50 to 60 per cent. But, of course, much smaller profits must be looked for during the first two or three years. If the young seedsman is making a living, he should be content provided he sees a prospect of making headway. With the small capital mentioned he could not afford to give long credit. In country towns it is almost necessary to give some credit, however; but the man with a restricted capital should look keenly after his accounts. It is a practice with owners of large estates to allow their head-gardeners or stewards a certain amount at the bank to operate with, and, especially as he becomes better known, the seedsman has often to wait twelve months for his bill. This must be allowed for in a higher price for the goods when invoiced. The typical seedsman's profits are generally reckoned at 10 per cent. on cash transactions, 20 per cent. on quarterly accounts, 25 per cent. half-yearly, and 45 per cent. yearly. The net profit should range at not less than 10 to 20 per cent. on the turnover.

SEWING MACHINE DEALERS

The selling of sewing machines may well be undertaken as a side line by many shopkeepers—drapers, ironmongers, cycle agents, sporting goods dealers, and many other retailers. The stock is not expensive, and its variety not unduly large. Sewing machines do not easily soil with ordinary care; fashion does not change the nature of the public taste as in many other branches; and, finally, the profits are very good. For these reasons a small stock of sewing machines may well be bought by the retailer whose main business consorts well with the sewing machine trade.

Stock. The trade in sewing machines may be divided into two classes—the family trade and the manufacturing trade. When it is desired to embark in it to only a small extent, and with the smallest disbursement of capital, the dealer is well advised to confine himself to the family trade. Should he

have capital to spare he may purchase one or two machines for tailors' use, but for manufacturing purposes on a larger scale he should refrain from holding stock, contenting himself with selling from the catalogue. Factory installations of sewing machines are keenly competed for, but the order is usually a good one, and the task of keeping the machines in repair can usually be secured by the man who supplies them if he be in the district.

The draper, or other shopkeeper, who wishes to stock sewing machines on a very modest scale may enter the trade with the expenditure of not much more than a ten-pound note. He can purchase, say:

1 High arm family machine	£2 10 0
2 Ditto, with extended leaf table ..	£5 10 0
2 Ornamental covers..	0 18 0
2 Hand machines, with covers.. ..	£4 6 0
	£13 4 0

With this stock he can make an impressive window display, and do quite as much trade as he could with double the number of machines.

In some districts a hand machine mounted on a stand with treadle attachment, and detachable therefrom, is sold in some quantity. It is convenient and gives the user the advantage of the hand machine as well as those of the treadle machine. The cost price of such a machine is 15s. to 20s. more than of a hand machine.

Local preference plays some part in the kind of machines sold in a district. In this country, for instance, treadle machines are sold in overwhelming numbers; but in British Colonies, South Africa for instance, hand machines are sold five or ten times more than the larger models.

The bulk of the sewing machines sold by private traders in this country are of German manufacture and are purchased through the wholesale agents resident in this country. But British machines can be obtained for about the same prices, although the finish of the German machines is better than that of English machines at the same price. American machines are also sold, but chiefly direct to the public by the representatives in this country, so that practically choice of the market lies between English and German manufactures.

Profits. Retail lists of sewing machines are usually drawn up so that the retail prices shown represent double cost prices. The list is usually adhered to in selling on the instalment system, and for cash transactions a discount of from 10 to 25 per cent. is given. The profit seems good, and it is. But there is an enormous difference between gross and net profits. The expenses of canvassing and collecting, of upkeep, and of loss by bad debts has to be met out of the apparent 100 per cent. profit on cost prices, and cash business, although at a considerable discount, is much more welcome to the dealer. It is not often that there is inducement to cut prices much in the sewing machine business. The chief competition comes from large manufacturing companies with expensive systems of distribution, and the prices of these companies are based on a higher scale than those we have given.

Some cautions regarding the hire-purchase system of business are given on page 704.

Old Machines as Part Payment. It is frequently necessary to take an old sewing machine as part payment for a new one. The customer usually has exaggerated ideas regarding the value of his old machine, which, in the auction-room or as old iron, is not worth more than half-a-crown. The dealer must make an allowance for the old machine, taking no consideration of what he may expect to realise for it. One large company follows the practice of allowing 20s. from the price of a new machine for any old machine taken as part payment. This allowance, of course, comes out of profit, which must be on a scale high enough to stand it.

Repairing. The repairing of sewing machines is properly undertaken by those who sell them. A fair trade may be done in selling them only, but here as elsewhere the public like to purchase where they can have repairs executed. The dealer who has to send to be done elsewhere the repair work that inevitably comes to him labours under a disadvantage. Repair work is remunerative. The average owner of a sewing machine is ignorant of matters mechanical, and the mere adjustment of a screw or tension, or a drop of oil given in the right place may usually be charged for at a good price. In framing the scale of repair prices, a minimum charge of, say, one shilling, should be adopted. Claims for payment of repairs should be made not so much upon the actual time taken in their execution—although no charge should be less than a fair return for the time spent at the work—but upon the value of the service rendered. No charge can be made for adjustments and reasonable repairs to a machine which has been sold for cash less than twelve months before or to a machine sold on the hire-purchase system and not yet fully paid up.

No instructions can be given regarding sewing machine repairs. The same qualities which go to the making of a successful watch repairer or cycle repairer make a good sewing machine repairer—namely, the ability to reason back from effect to cause in mechanical matters, a well developed mechanical aptitude, and handiness with the screwdriver. A careful study of the mechanism of a sewing machine, the task of dismounting and re-erecting it, and an examination of the functions of each individual part will do more to make a man a sewing machine mechanic than tomes of printed instructions.

The chief point which the shopkeeper handling sewing machines has to decide is whether he will make the trade a cash one or if he will invite orders from buyers, who will purchase only on the so-called "hire-purchase" system. Both methods of doing business have their advocates, and both have their points of recommendation. Unless the shopkeeper is prepared to establish a thorough system of canvassing and of instalment collection along with the necessary system of bookkeeping, or if he have not cash available to finance an instalment business, he will be wise to restrict himself to cash trading. The instalment method should not be attempted unless the capital at command be at least £500. To attempt it on less than this sum is to remain for a good time under the necessity of restricting the extent of the business to small dimensions or to risk collapse by an overload of assets in the form of book debts which cannot be realised when desired and when needed.

Continued

RECIPROCATING AND ROTARY TOOLS

Principles of Reciprocating and Revolving Tools. Planing, Shaping, Slotting, Drilling, Slot-drilling, and Boring Machines

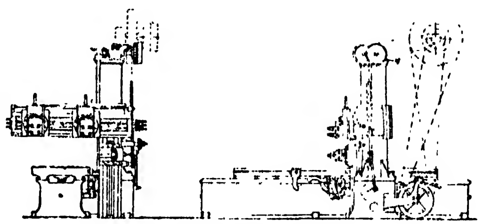
MACHINE TOOLS
continued from page 4924

By FRED HORNER

A MACHINE TOOL may be defined as the combination of a tool and a machine arranged so that the tool is operated and controlled with precision, instead of depending on the human element, as is the case with a *hand tool.* In most metal-working operations the advantage is all on the side of the machine tool; it is able to do nearly everything that the hand tool can, and a good deal besides. The valuable property of *guidance* possessed by machine tools is also combined with that of *power,* which means that the *capacity* or *output* of hand-worked tools is immensely exceeded by machine tools, so much so in many cases that certain work could not be produced by hand methods at all, or only in an imperfect manner and at great cost. In a modern machine shop we find a large variety of machines engaged in working castings and forgings, while the only handwork done (in the fitting shop) is chipping, filing and scraping—a little chipping and filing where it has not been worth while sending a piece to the machines, and scraping as a fine finishing process on high-class work. All the rest is effected with machines that plane, shape, slot, drill, bore, face, mill, screw, and grind.

A distinctive difference between machine tools and some other mechanisms lies in their relative accuracy of construction. A machine tool has to produce accurate surfaces by virtue of its inherent build, and its parts must therefore have true rectilinear movements, and spindles and slides must move without shake or slackness. Something beyond mere fitting of portions together is involved; they have to be made or adjusted to pass certain tests, and provisions for taking up slacknesses due to wear are necessary in order to provide for the future.

Principles. Machine tools are divisible into two great groups, the *reciprocating* and the *rotary.* In the first-named the movements of the tools (or the work) are linear; in the second, revolving tools are employed. Planing, shaping, and slotting machines represent one type; drilling, boring milling, screwing, and grinding machines the other. The first class cut intermittently—having a non-cutting *return stroke*—the second operate continuously. This makes an essential difference to the *feeds,* or movements by which the area to be tooled is gradually covered. In the reciprocating machines with non-cutting backward stroke a definite lateral movement or feed is imparted to the tool or the work after each stroke or cut: in the rotary machines feeding may be continuous. The *speeds* are the rates of cutting, and the feeds are intimately related thereto, since their amount must depend on the

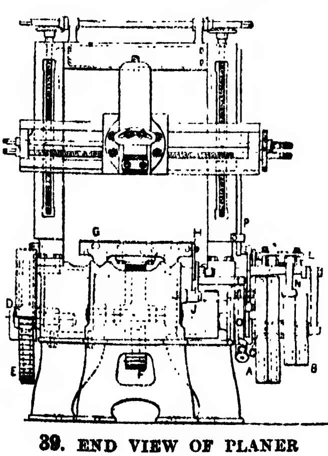


41. OPEN-SIDE PLANER

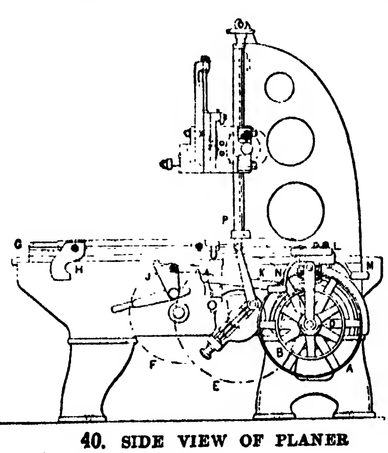
capacity of the tool or the work to withstand the strain of a given cut at a certain speed. There may be either a high speed and a light cut, or a low speed and a heavy cut.

Provision must be incorporated for obtaining different rates of speed and feed, to suit the various materials and classes of operations dealt with. Arrangements for holding down the pieces of work and for gripping the tools are also essential. Devices for rendering the machines more or less self-acting or automatic in action are necessary for economical reasons as well as to produce good work. If a machine does not need the services of an attendant to effect certain motions or reversals, then he may be usefully engaged elsewhere, perhaps on another machine, in setting or removing work.

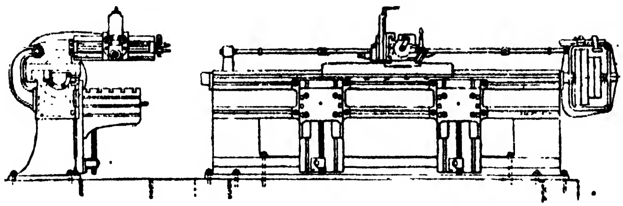
Means must be afforded of setting or adjusting portions precisely, in order to tool the work to close sizes. Other subsidiary matters are: efficient lubricating devices for spindle bearings and slides, and lubrication of another character for flooding the work and tools during cutting; protection to vital parts of the machines from the chips and dust produced during working, which would otherwise cause damage to the surfaces



39. END VIEW OF PLANER



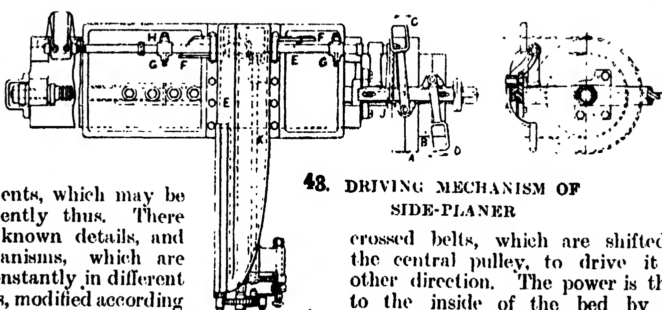
40. SIDE VIEW OF PLANER



42. RICHARDS SIDE-PLANER

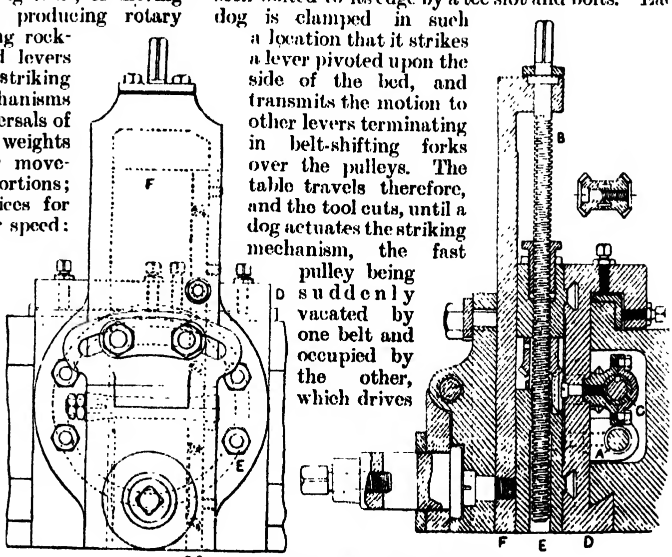
and bearings. Some movement or travel is necessary in all cases to tool surfaces, which movement may be imparted either to the work or to the tools. It is sometimes a matter of indifference which course is pursued, while in certain cases a decided advantage is gained by one method over the other. For example, some especially massive castings are machined while stationary, the tools themselves travelling, while an immense quantity of smaller pieces are commonly tooled by moving them past the cutting tools. It is scarcely a question of relative accuracy or truth of surfaces, but one of convenience primarily.

We do not need to take up the description of the various details of machine tool construction here, as in the article on the lathe, because typical complete drawings are shown, containing the elements, which may be studied conveniently thus. There are certain well-known details, and particular mechanisms, which are found to recur constantly in different types of machines, modified according to their applications. Mention may be made of beds carrying other beds, or slides or tables, which are tee-slotted to receive clamping bolts; tool slides with saddles and tool-holders, circular spindles, carrying tools, or driving bars; pulleys and gears for producing rotary motions; levers for transmitting rocking action; screws, racks, and levers for causing to-and-fro motions; striking gears or trips for throwing mechanisms out of action or producing reversals of direction of motion; balance weights for counteracting the irregular movements of heavy sliding portions; clutches and belt-shifting devices for stopping or change of motion or speed: quick-return mechanisms, by which the wasteful backward stroke of tables and rams is accelerated, and its duration shortened.



43. DRIVING MECHANISM OF SIDE-PLANER

Planing Machines. After the lathe, the *planing machine* is the primary machine tool in a shop, doing for plane surfaces what the lathe does for circular ones. By its means linear portions are machined at right or other angles to each other. Great lengths are tooled, either in one casting or on a number set in line. The method by which these operations are accomplished is to provide a long table, sliding beneath the tools, and so carrying the work past them, while feeding is done at each interval between strokes. This feeding may be either across or up and down, or angularly, according to the disposition of the faces on the piece being treated. These conditions are met by the design in **45**, in which the deep *bed*, resting on the floor, provides a runway for the slotted table, moving with vees on the bed. Two uprights, or *housings*, are fastened to each side of the bed, and support a *cross-rail* upon their vertical faces. This rail can be moved up or down by the handle seen, operating mitre wheels, and vertical screws within the housings, working in nuts attached to the rail. A *saddle* slides across the rail, driven by means of a screw, and a *slide* and *tool-box* is bolted with a circular facing on the saddle to enable the tool to be set angularly. A small range of vertical motion is given to the tool-slide by handle and screw, or self-actingly. The cutting is done while the table is travelling towards the tool-box, the latter being pivoted to let the tool drag lightly when on the back stroke. The table is driven by the pulleys seen at the side, there being three, one fast central one, and two loose side ones. The latter carry open and crossed belts, which are shifted in turn on to the central pulley, to drive it in one or the other direction. The power is thence transmitted to the inside of the bed by spur gears, terminating in a large spur, called a *bull-wheel*, which meshes with a rack attached to the underside of the table, and so drives the latter. The automatic reversal of the table is effected by the *dogs* or *stops* seen bolted to its edge by a tee slot and bolts. Each dog is clamped in such a location that it strikes a lever pivoted upon the side of the bed, and transmits the motion to other levers terminating in belt-shifting forks over the pulleys. The table travels therefore, and the tool cuts, until a dog actuates the striking mechanism, the fast pulley being suddenly vacated by one belt and occupied by the other, which drives

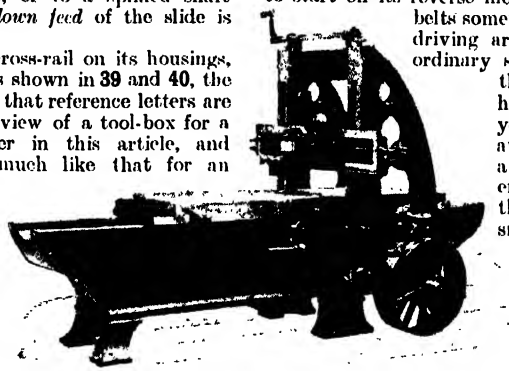


44. TOOL-BOX OF SIDE-PLANER

in an opposite direction. At the moment of reversal a feed is given to the tool-slide by a vertical rack-bar placed behind the cross-rail and reciprocated up and down by a small crank disc driven from the table gears. As the rack-bar moves a little, it partly rotates a toothed wheel, which by a ratchet device gives a partial rotation to the *feed-screw* lying inside the cross-rail, or to a splined shaft above it, by which the *down feed* of the slide is obtained.

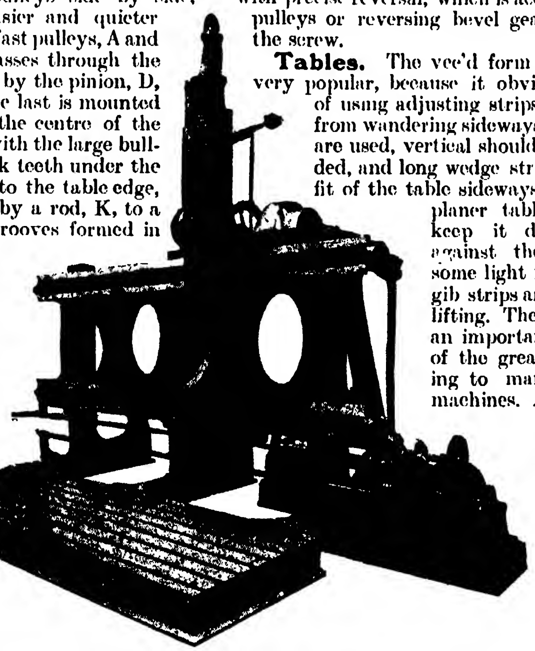
The arrangement of a cross-rail on its housings, with saddle and tool-box is shown in **39** and **40**, the parts being clearly seen, so that reference letters are unnecessary. A sectional view of a tool-box for a side-planer is shown later in this article, and its construction is so much like that for an ordinary planer that we need not give space to illustrate the latter also.

Driving Mechanism. The drawings, **39** and **40**, of a machine by Cunliffe & Croom, Ltd., Manchester, include the driving mechanism. It does not embody the three pulleys described in connection with **45**, but has two sets of fast-and-loose pulleys, each set having its own driving belt, and a difference being made in the diameters to produce a rapid rate of return. This method has some advantages over the other by using three pulleys side by side, chiefly in the direction of easier and quieter reversal. In **39** and **40** the two fast pulleys, A and B, drive the shaft, C, which passes through the bed, driving on the other side by the pinion, D, to the large spur wheel, E. The last is mounted on a shaft going through to the centre of the bed, where a pinion meshes with the large bull-wheel, F, engaging in the rack teeth under the table, G. The dog, H, bolted to the table edge, strikes a lever, J, connected by a rod, K, to a sliding plate, L. L has cam grooves formed in it, which coerce pins as it slides, and shift the belt forks, M N, in turn. The disc, O, on the shaft which carries E operates the rack-bar, P, by an amount variable by a screw within the disc. The ratio between cutting and return stroke in this machine is 3¼ to 1. Twenty feet per minute was formerly considered satisfactory for planer tables, but this is much exceeded now in the best machines, rates up to as much as 60 ft. being obtainable when desired. Return strokes run as high as 225 ft. per minute in the most efficient machines. In order to obtain an easy reversal and start at such high speeds, several kinds of *cushioning* devices have been evolved, comprising springs which give sufficiently to absorb the shock of reversal. In one design the table rack is not bolted solidly, but has a certain amount of endlong freedom, coiled springs being placed at the ends, so that when the drive comes on suddenly, the rack gives way slightly and the table is started smoothly. In another firm's machine a coiled spring is combined with a claw clutch in such a way that the clutch begins to drive gradually, instead of with a positive jerk. In both of these mechanisms the energy stored up in the springs during the stroke is made to help the table to start on its reverse movement, so relieving the belts somewhat. Other methods of driving are employed, besides the ordinary spur gears and rack. In the Sellers drive, which has been applied for many years, a driving shaft is set at an angle in the bed, and a quick-pitched spiral gear engages with a rack under the table, producing a very smooth motion, which admits of high return speeds. The heaviest planers are driven in many cases by large square-threaded screws revolving within the bed, and moving the table by nuts attached to the under side. The nuts are made in two portions, so that they may be closed up in order to absorb slackness, or play between the threads due to wear. If there were noticeable backlash, it would interfere with precise reversal, which is accomplished by belt pulleys or reversing bevel gears on the end of the screw.



45. STANDARD PLANING MACHINE

Tables. The vee'd form of sliding ways is very popular, because it obviates the necessity of using adjusting strips to keep the table from wandering sideways. When flat slides are used, vertical shoulders must be provided, and long wedge strips, to preserve the fit of the table sideways. The weight of a planer table is sufficient to keep it down and steady against the cut, except in some light machines, in which gib strips are fitted to prevent lifting. The oiling of a table is an important matter, because of the great weight, amounting to many tons in large machines. As the oil would be quickly squeezed out of the ways, it is kept constantly applied, by means of rollers resting in pockets or recesses in the bed, these pockets containing oil, which floats the rollers, and keeps them constantly smearing the table slide-ways with lubricant. In addition to the longitudinal tee slots on the top of the table, a large number of holes are reamed in it, to carry *stop plugs*, by which the thrust of work is received.



46. VERTICAL AND HORIZONTAL PLANER (Hulse & Co., Ltd., Manchester)

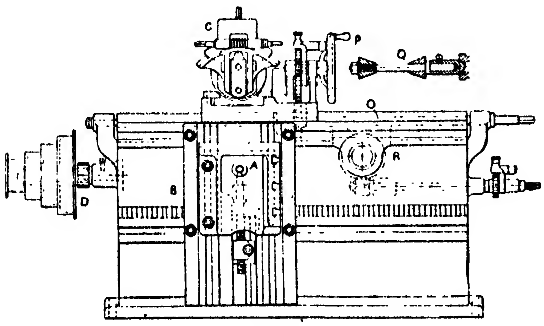
The larger planers have two tool-boxes on the cross-rail, and also one on each housing face, for planing the sides of work. Modifications are made in

the forms of planers to accommodate special work. In *frog* and *switch* machines for railway work, the housings are low, because the work is shallow. In the *roller-fluting* machines a number of tool slides are fitted, and centres are mounted on the table to receive several rollers, which are fluted simultaneously. Nuts are also planed in a similar way upon mandrels.

Open-side Planers. *Open-side*, or *single-standard* planing machines are designed to take pieces of work which are too wide to pass between the housings of an ordinary planer. A machine of this class is shown in **41**, having a rail or arm supported by a circular column, which itself carries a tool-box for side work. The rail has two boxes, actuated automatically in the manner already described. The table, from which pieces may overhang without obstruction, runs on flat ways. Its cutting and return strokes are effected through the large and small pulleys at the side, driven by open and crossed belts. A small pulley on the countershaft (shown dotted) drives to one on the column, connecting to spur and bevel gears, which drive a vertical screw for raising and lowering the arm.

Double-cutting Machines. In the machines described previously, cutting takes place only while the table is travelling in one direction. To avoid the waste of time thus involved, double-cutting tool-boxes have been devised, to make the tool (of special form) cut in two directions alternately. These devices are used only to a limited extent by comparison with the number of ordinary planers employed. The original design—the Whitworth—consists of a round socket within which the tool is gripped, and given a half revolution at each reversal, so bringing the cutting edge into action first on one side and then on the other. The rotation is effected by cords passing over pulleys on the cross-rail and around the tool socket. The peculiar jumping round action of the device led it to be termed a "Jim Crow." In other fittings, the object sought is not to rotate, but to tilt the tool in its box in two directions, the end of the tool being made with double edges, which cut alternately.

Special Planers. *Pit* planing machines are radically different from ordinary machines ; instead of possessing a travelling table, a large pit lies below the cross-rail, and the latter, with its housings, travels on guideways flanking the pit. Extremely massive objects may be held stationary and tooled. Armour plates are examples of the work so done.



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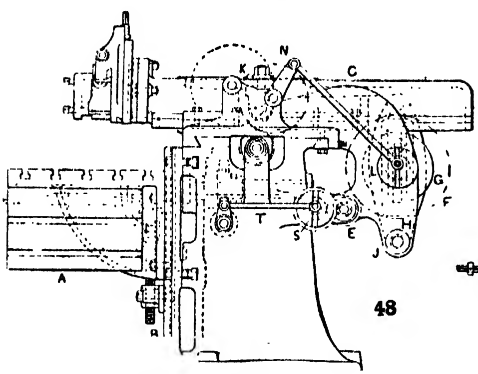

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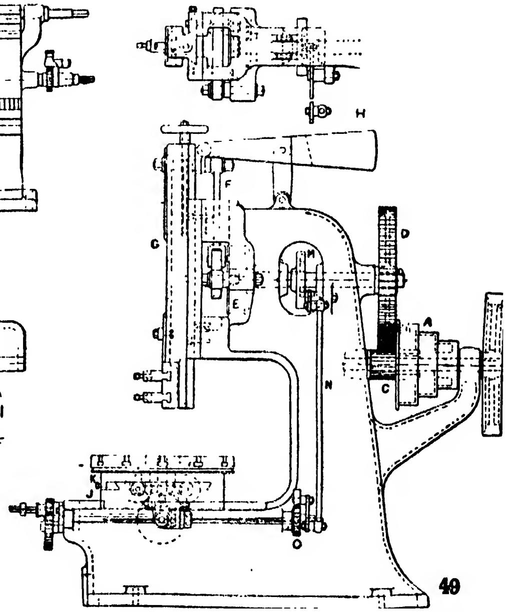
47 AND **48**. CRANK SHAPER



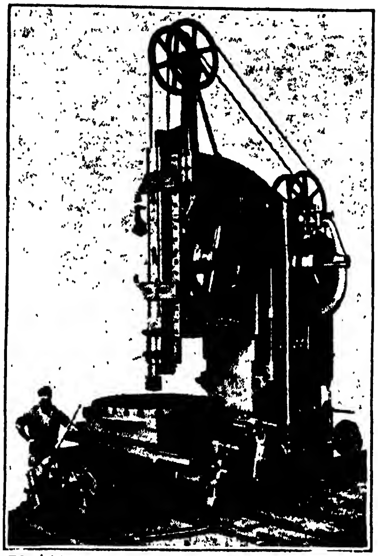
49. SLOTTING MACHINE

Vertical and horizontal planers also serve for massive work which is not convenient to put on a moving table. Large marine engine castings are planed in this way. The machine [**46**] comprises a base plate to hold the work, which is operated on by tools held in a saddle that travels up and down a long vertical slide. The latter travels bodily for horizontal planing upon two slideways on the face of the vertical framing. Large, square-threaded screws are employed to drive the slides, and the feeding is performed in a similar manner, changes being obtained by gears.

Side-planers. We have seen that the open-side planer possesses advantages for tooling bulky work. There is another machine, the *side-planer*, that is even more useful, though its construction is different, the tool travelling instead of the table. The fact that the table is fixed, and consequently the

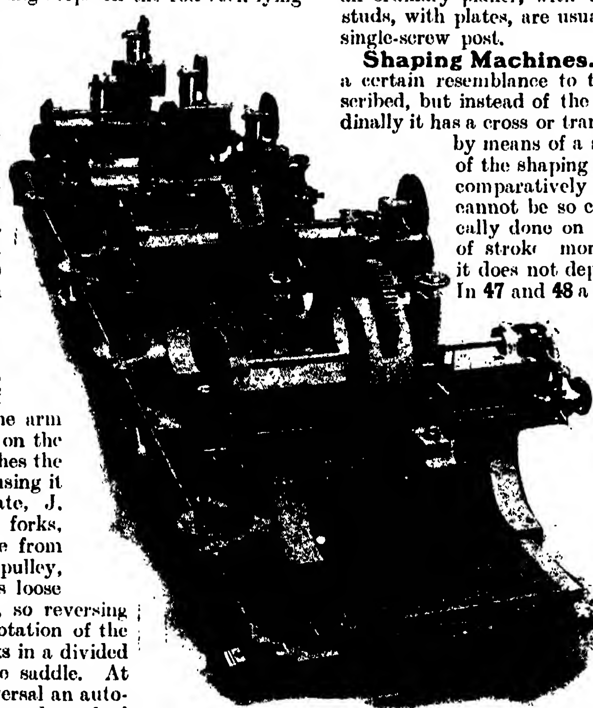
work does not move, simplifies the attachment of the latter, and no matter how much its overhang, it can be supported with blocking and wedges. The Richards side-planer (by Geo. Richards & Co., Ltd., Broadheath), shown in **42**, an example having a stroke of 6 ft., comprises a framing, on the front of which facings receive flat plates, held anywhere on the length with tee-headed bolts in slots. To each plate is fitted a *box* table, with tee grooves on three of its sides. The tables are raised and lowered by the screws operated through bevel gears from squared spindles rotated with crank handles outside. The four bolts seen at the front of each table tighten the latter after adjustment. The tables may be used separately for different pieces of work, or to support a single large piece between them. There is a brickwork pit in front of the machine, into which deep pieces may hang. The saddle, with its arm carrying a tool-box, travels along the top of the bed, being driven to and fro by a square-threaded screw inside it, revolved alternately by the large and small fast-and-loose pulleys at the end. The belts on these pulleys are moved by the action of the saddle striking stops on the rod seen lying above the bed. The details of this mechanism are shown in **43**—a plan view of the saddle and driving mechanism and end view of the striking gears. The fast pulleys are marked A and B, and the belt forks are shown both over the loose pulleys, in which position the machine would be idle.

When running, the arm, E, travels along until one of the *horns*, F, on the arm strikes a stop, G, on the rod, H, which pushes the latter endwise, causing it to slide the plate, J, which coerces the forks, C, D, moving one from its fast to its loose pulley, the other from its loose to its fast pulley, so reversing the direction of rotation of the screw, which works in a divided nut screwed to the saddle. At the moment of reversal an automatic cross feed, or a down feed is given to the tool-box, not shown in this view, on the arm, E. The horns, F, have spiral edges, so that in striking G they give the rod, H, a twist, which is transmitted through encircling mitre gears to shaft, K, passing through the arm to the front, where quadrant gears and a ratchet device transmit the motion to either the feed screw, or the feed rod, which lie within the face of the arm. The tool-box [**44**] slides across the arm by the vee and square gib fitting. If may be fed across, or downwards by the square ends of the operating screws seen, A and B. The automatic cross feed is effected when the screw, A, is moved by the ratchet devices shown in **43**; the down feed operates when the splined rod, C, revolves, and communicates its motion through the mitre gears seen to the screw, B. The mitres passing through the saddle, D, are screwed and pinned together, as seen in the detail shown on the drawing. The intermediate plate, E, may be revolved and bolted in any angular position on the saddle, D. The slide, F, is the one that is fed down by the screw, B; it carries the *tool-holder*, hinged to allow the tool freedom on the back stroke, the device being termed a *clapper box*. A single pillar holder is provided for the tool. The whole construction of this tool-box is identical with that for an ordinary planer, with the exception that four studs, with plates, are usually fitted instead of the single-screw post.



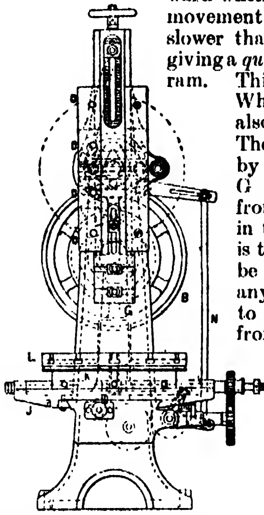
50. 54-IN. GEARED SLOTTING MACHINE (Niles-Bement-Pond Co.)

Shaping Machines. *Shaping* machines bear a certain resemblance to the side-planer just described, but instead of the tool travelling longitudinally it has a cross or transverse stroke, produced by means of a slide or ram. The value of the shaping machine lies in tooling comparatively short lengths, which cannot be so conveniently or economically done on the planer. The length of stroke moreover, is precise, since it does not depend upon shifting belts. In **47** and **48** a typical shaper (Tangyes, Limited, Birmingham) of 12 in. stroke is shown in front and end elevations. There is a table, A, elevated with screw, mitre gears, and handle shaft, clamped against a plate, B, adjustable along the front face of the framing. The driving of the *ram*, C, is through the *cone* pulley, D, thence from pinion, E, to wheel, F, which revolves a short shaft carrying a *crank disc*, which has a pin and block fitting in the slot in a large link, H. The latter is pivoted to the bottom of the saddle casting at J, and at the other end has a connecting rod coupled to the ram by a bearing clamped at any



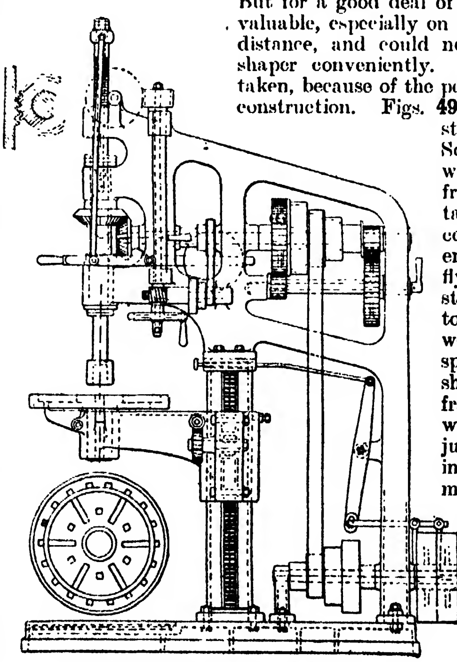
51. FRAME-PLATE SLOTTER (J. Hetherington & Sons, Ltd., Manchester)

position in a slot by a nut, K. As, therefore, the disc, G, rotates, its pin and block go around and force the link, H, to rock on its pivot at J, and to reciprocate the tool ram from the other free end. The forward stroke of the ram occurs when the sliding block is in the upper part of the slot in the link, and the backward when in the lower part, the movement in the first case being slower than in the second, thus giving a *quick-return* stroke to the ram. This device was one of Whitworth's inventions, also applied to planers. The stroke is adjustable by bringing the pin in G closer to or farther from the centre. The slot in the top of the ram, C is to allow the nut, K, to be slid and tightened at any convenient location to make the ram start from a certain point on a piece of work. After each stroke of the ram it has to be moved bodily sideways to impart feed, and this is derived from a slotted disc, L, on the same shaft as G. L rocks a connecting rod, coupled to a ratchet lever, N, intermittently operating a wheel (shown dotted) and thence a nut encircling the feed screw, O. The hand wheel, P, may also be used to feed by. The tool-box on the ram, C, has a hand down feed, and also swivelling motion by worm and worm quadrant, enabling the tool to be set to an angle, or gradually worked round to shape out a concavity. An important fitting is the *circular motion*, shown detached at Q. It is inserted in a hole in the frame at R, and consists of a bearing and *mandrel* holding an *arbor* on which two cones are placed, one being adjustable by nut to close up. Bosses and other pieces with holes in are held and centred by these cones, and as the tool above shapes the periphery, the work is intermittently rotated until a part or whole circle is tooled. There is a worm wheel mounted on the mandrel, and turned by a worm [47] which is worked by a ratchet device similar to that at N, but operated from a crank-disc, S, and connecting rod, T.



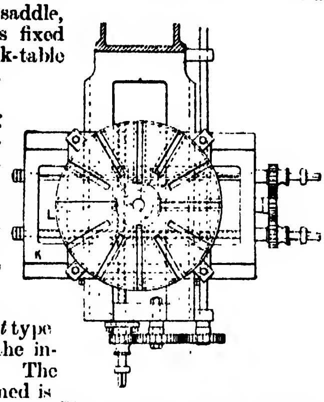
52. SLOTTER—FRONT VIEW

Machines of this class are constructed also with two tables, and also with two heads, to be used each on a separate piece of work, or both on one job. Other variations in shapers include swivelling tables, by which work may be angled, and the addition of self-acting down feed to the tool-box.



54. FRAME DRILLING MACHINE

Some machines also are rack driven, like planers, the reverse being effected by open and crossed belts on pulleys, or by friction clutches. In such machines the rate of travel is constant during the stroke, whereas with the Whitworth crank drive just described it must necessarily vary continually, on account of the changing radii. The smaller shaping machines do not derive their feed from the side motion of the saddle, but the latter is fixed and the work-table slides upon a saddle, self-acting feed being given by a screw, with crank-disc and ratchet, as in planers. All shaping machines cut on the outward stroke, with one exception, the *draw-cut* type which cuts on the inward stroke. The advantage claimed is that the pressure tends to draw the slides up together instead of pushing them apart, as on the outward stroke, and that the ram does not tend to tilt up as when pushing out. These points may be considered as reasonable in the case of poorly built or worn machines, where the tendencies mentioned would be noticeable, but not in machines kept in good condition, so that the draw-cut device is not followed to any extent.



53. PLAN OF SLOTTER TABLES

Slotting Machines. *Slotting* machines are not suited for such a general range of work as planers and shapers, because they lack the capacity for length of the first, and the handiness of the second. But for a good deal of short-stroke work they are valuable, especially on pieces that stick out a long distance, and could not be put on a planer or shaper conveniently. Very heavy cuts may be taken, because of the peculiar characteristics of the construction. Figs. 49, 52 and 53 show an 8-in. stroke slotter by John Stirk & Sons, Halifax, in elevation, with a plan of the head, front view, and plan of table. Driving begins at the cone pulley, A, a store of energy being conserved by the flywheel, B, to assist the stroke of the ram when the tool suddenly encounters the work. A pinion, C, drives the spur-wheel, D, keyed on a shaft passing through the frame to a crank disc, E, which is provided with an adjustable pin and block driving a pivoted link in the same manner as described in connection with the shaper [47 and 48]. The connecting rod, F, is pivoted to a pin held in the ram, G, the pin being adjustable by hand wheel and tightened by nut, plate, and serrations on the ram face, to bring the ram to the

most convenient location for a given piece of work. The balance weight, H, prevents jerky motion of the ram. The tool is gripped by the *straps* at the bottom end, and the tool is prevented from slipping up by the stop-block bolted on the face. The table slides comprise a saddle, J, an upper slide, K, and a *circular table*, L, providing for movement to and from the column, transversely thereto, and a circular motion. The feeds are derived from a disc, M, which has a cam groove in its face, coercing a pin in a lever, and rocking the connecting rod, N, which has a ratchet fitting to feed the wheel, O, intermittently. O is on a splined shaft lying below the slides, and connection is made to the operating screws within these by mitre wheels and spur wheels, the actions being thrown in or out by sliding pinions. The rotary motion of the table is effected by a worm and wheel [see **49** and **53**]. All the motions may be operated by hand also. When not required to revolve, the table is clamped with four plates round the bevelled edge [**53**]. The hole in the centre receives a mandrel for holding circular work by. When taper keyways have to be slotted, tables are made with a hinge arrangement, by which a slight amount of tilt can be imparted to throw the work over, and so slot out of parallel.

The ordinary slotter has no provision made for relieving the pressure on the tool during the return stroke, but some are supplied with a hinged box, similar in principle to the clapper box of a planer: others have it embodied in the tool bars.

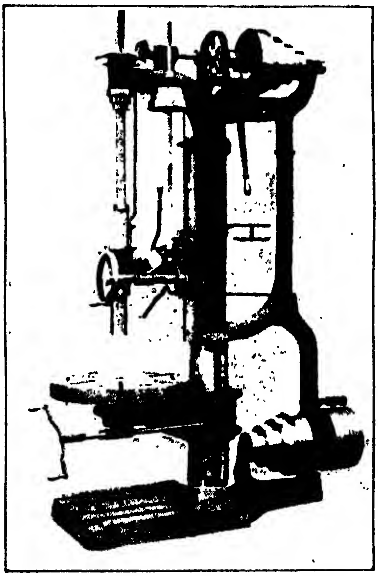
Variations from the ordinary practice include the getting of quick-return by *elliptical gears*, formed in half portions, which alternately come into action, and give slow and rapid strokes for cut and return; the addition of tool clamps on the *bottom* of the ram, to hold special tools; driving the ram by screw, or by rack in the large machines. Fig. **50** is a fine example of a heavy machine, the stroke being 54 in. It is rack driven, and reverses its motion like a planer, with shifting belts on fast and loose pulleys. The counter-balancing is done with weights at the back, connected by steel wire ropes passing over pulleys to the ram.

Frame-plate Slotters. *Locomotive frame-plate slotting machines* bear little resemblance to the ordinary slotters, except in possessing vertical rams. Several of these are mounted on cross-rails and heads [**51**, which is a four-head machine], and they are fed along or across to slot out the shape of the frame-plates, a pile of which is bolted down to the table to be operated on. The heads are travelled along the bed by screws at the sides, and the driving of the heads is effected from a splined shaft seen running up the length of the machine on the left-hand side, driving bevel gears which communicate motion to cross shafts above the rails. Drilling attachments are also fitted to the heads for drilling the holes in the plates at the same setting. The entire machine is driven from an electric motor at the far end.

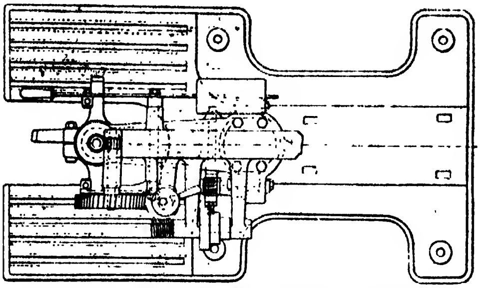
Drilling Machines. Drilling machines and boring machines are a large group embracing many types, for small or large work, of horizontal or vertical designs, with provisions for drilling or boring one or several holes simultaneously. A drilling machine is strictly one for originating holes, a boring machine one for enlarging them, though the distinction is not always rigidly observed. In a drilling machine the essential points are means for rotating the drills, feeding them to their work or vice versâ, clamping the work, and adjusting it or the drill to exact positions. Small pieces of work may easily be shifted about to come underneath spindles, but massive ones are troublesome, and preference is given to moving the drill instead.

A machine embodying many features which are common to several other types of drills is that in **54** and **56** (John Stirk & Sons, Halifax), what is termed a *frame* drilling machine. The *spindle* is of 3 in. diameter, with a vertical feed of 16 in. It runs in sleeves within the head. The drive is from the fast and loose pulleys on the base of the frame, the belt being thrown over by forks actuated through the pivoted levers seen, ending in a small knob at the front of the column, close to the operator. The four-step cone pulley at the base drives up to its companion within the opening above. The *back gears* there give an increased power when necessary. A horizontal shaft runs thence through the frame, driving a mitre gear, engaging with one mounted on a sleeve encircling the spindle. This is a device to prevent the injurious side-pull caused when a wheel is mounted direct on a spindle. The feeding down of the spindle is done either by hand, turning the hand wheel on the vertical shaft seen close to the spindle, ending in a worm which revolves its worm wheel, and thence a pinion gearing in a rack cut on an extension of the spindle. The teeth are shown enlarged. The vertical hand-wheel shaft is mounted in an eccentric quill in order that the worm may be thrown out of gear by a part rotation, using the handle screwed into the quill as a lever. Self-acting feed is imparted by the small three-step cone pulleys driving from the back-gear spindle down to one which has a worm actuating a wheel on the vertical shaft, a friction cone clutch inside making provision for throwing the feed in or out of action. For light drilling or countersinking, the spindle may be fed down rapidly by hand, using the horizontal lever seen below the driving mitres. This lever is connected up to the top of the spindle by a loose collar thereon and side connecting rods. A circular weight is used to counterbalance the load and draw the spindle upwards on releasing the handle. The weight is partly hidden behind the frame.

The circular work-table of the machine is carried in an *arm* that swivels around its circular *column*, and is moved up or down it by a pinion meshing with a rack that is held inside the arm and turns around the column freely, but cannot move endwise. The pinion is revolved by a wheel turned with a worm operated by a handle. Work that is too



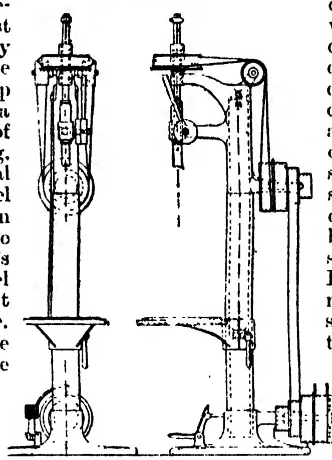
55. PILLAR DRILL



56. PLAN OF FRAME DRILLING MACHINE

bulky to go on this table is accommodated upon the base plate, tee-slotted for bolts.

Pillar Drill. A type of machine that has received its greatest development in America is shown in **55**. It is a *pillar* or *column* drill, with *sliding head*, the latter having reference to the lower bearing of the spindle, which is slid upon a vertical face, the object being to bring the bearing down as low as possible for steadying the spindle close to the work. The driving arrangements are very similar to the last example. The back gears are slightly different, and the bevel-gear drive to the spindle is above the top bearing. Feeds are obtained from a three-step cone on the extension of the spindle bevel in the top bearing, a belt driving to cones on a vertical shaft adjacent. This actuates bevel and worm gears, which rack down a sleeve encircling the spindle in the lower bearing. The same effect is produced by turning the hand wheel near the bearing, or pulling the short upright lever behind the spindle. Both spindle and lower bearing are balanced with weights inside the column suspended by chains. Numerous modifications are made in designs which include these features.



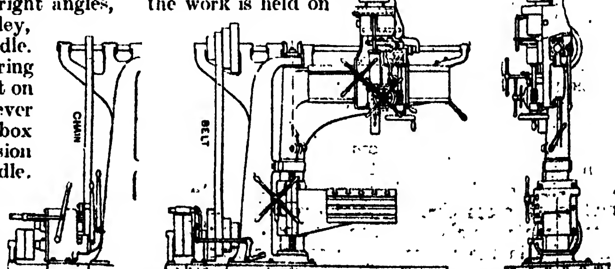
57. SENSITIVE DRILL
(Webster & Bennett, Ltd.)

Sensitive Drill. Another kind of pillar drill, shown in **57**, is of the *sensitive type*, used for drilling small holes at high speed. No toothed gears are required, the capacity being only up to $\frac{3}{8}$ in. holes. There are fast and loose pulleys at the base, the belt is thrown over by the foot-treadle seen at the base, and the operator's hands are thus left free for manipulating work and feed. The fast pulley on the base is cast with the three-step pulley, which is belted up to another near the top of the column. Thence a belt is carried around two *idlers*, which change the direction to right angles, and lead the belt around the spindle pulley, running on a sleeve encircling the spindle. The latter is fed through the lower bearing by a rack and pinion, the rack being cut on a sleeve which does not rotate. The lever for feeding is screwed into a circular box containing a flat coiled spring, the tension of which always tends to raise the spindle. The operator can therefore feel the pressure he is putting on the drill, because there is no intermediate screw or any heavy weight to interfere with the delicacy of manipulation. The depth of drilling is determined by the *stop-collar* clamped on the spindle near the top, to touch the pulley at a certain point of the travel. The flat table is clamped on the column by a split lug tightened by a hand screw, and the weight of the table is counterbalanced by a weight inside the column. Machines of this type are also made with an abbreviated column, to rest on the bench.

Radial Drills. *Radial* drilling machines are designed to avoid the necessity of shifting the work about for every hole that has to be drilled, the drill being moved instead by means of a radial pivoted arm [**58**] carrying a saddle, which can be slid along to and from the column, so that the entire area of the table is covered. Some radials have the arm placed directly upon an independent circular pillar, around which it turns, but in the machine illustrated the column is supported by another pillar that serves to hold part of the driving gears. Two alternative methods of driving are illustrated; in the complete drawing fast and loose pulleys and stepped pulleys transmit the power to a horizontal shaft above the arm. In the part view to the left, fast and loose pulleys connect to a change-gear box, by which nine changes of speed are obtainable instantly through friction clutches and gears. By the use of double gearing in the saddle the changes are doubled, making 18 in all. From the *speed-box* a Renold chain transmits the power to the top shaft. This shaft connects with the saddle gears in any position, and drives the spindle, a friction clutch being interposed for easy starting, stopping, and reversing for tapping. Four different feeds are given by nest gears in the saddle, and the spindle may also be moved by the hand wheel adjacent to it or by the large cross-handle. The other cross-handle on the left-hand side of the saddle is for *racking* it along. The table is raised and lowered by pinion and rack, actuated by the cross-handle seen.

Some radials have a swivelling motion to the spindle, for drilling holes at angles: in others, the box tables swivel to tilt the work. Vertical movement of the radial arm is included in cases where very deep work is to be drilled.

A good many other machines differ chiefly in the form of framing adopted. Some possess uprights and cross-rails, carrying two or more spindles, and the work is held on



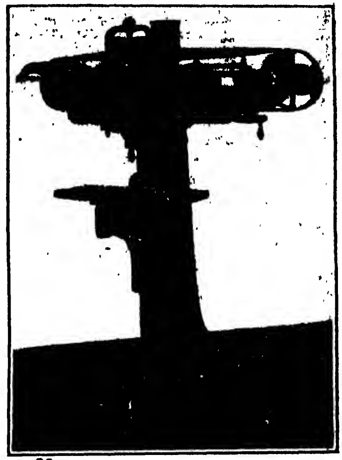
58. RADIAL DRILL (James Archdale & Co., Ltd., Birmingham)

a long table below. *Multiple-spindle* machines are constructed in numerous types, with the spindles duplicated side by side, or set to form various geometrical patterns. A design which can be employed in this way is shown in 59. The spindles are driven at one location, and they are branched out to any position required, and clamped so that certain definite arrangements of holes, as circles, squares, hexagons, etc., may be drilled simultaneously. The spindles are fitted with double universal joints, which permit of the angular positions.

The methods of holding drills in their spindles comprise *parallel shanks*, pinched with set-screws; *tapered shanks* and sockets, and *drill chucks*. The latter are used chiefly in the smaller machines.

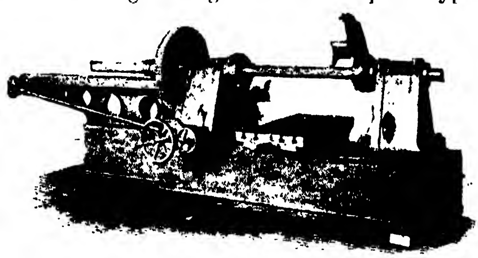
The advantage of the taper shank over the parallel one is that no slackness can occur with the former, while the latter, if it wears loose must remain so, and with the result that the drill runs out of truth. Drill shanks of taper form have a short flattened portion entering into a slot at the bottom of the hole in the drill spindle, so that a positive drive is given to the drill without depending on the friction of the taper alone. The drill is ejected from its spindle by driving a tapered cotter or key through the slot, which has the effect of pushing out the tail of the drill. To accommodate a good range of sizes, *sockets* or *sleeves* are necessary, otherwise it would be found that a small drill would need a very big shank to make it fit the spindle. But by putting a hollow socket inside the spindle, and inserting the drill in this, the shank of the drill may be made of a diameter about equal to its body. Morse tapers are employed as standards for taper shanks, so that interchangeability of all drills and holes is secured.

Chucks are only used on the small machines: they form a convenient method of holding shanks down to the smallest sizes, of parallel form, and any special drills can be readily held without troubling to turn the shanks tapered. Most drill chucks have either two or three jaws, sliding in a circular shell or body, and closed in by the action of screw threads operated by a knurled sleeve or by a square key. The chucks are, of course, self-centring.



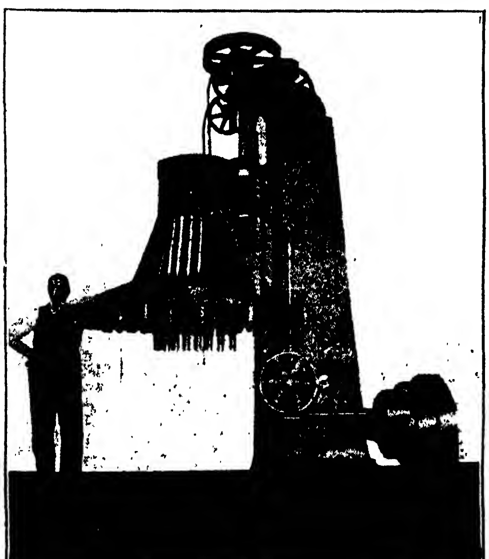
60. SLOT-DRILLING MACHINE
(Geo. Richards & Co., Ltd., Broadheath)

Angular-hole Drilling Machines. These are special types of drilling machines which perform operations different from the production of ordinary round holes. Square or *angular-hole* drilling machines cut out holes of polygonal shape with revolving tools, which have to be coerced to run into the angles. Square, hexagon, and octagon holes are commonly done thus, for spanners, handles, etc. One method is to pivot the drilling spindle about its centre in a ball socket, and to cause the top end to move inside a pattern plate of the shape desired. The angular motion is, of course, reproduced at the bottom of the spindle, and on putting in a suitable tool of knife-like section it cuts out the shape by running from corner to corner. Other devices are somewhat similar in principle, the use of a pattern or form-plate being necessary.

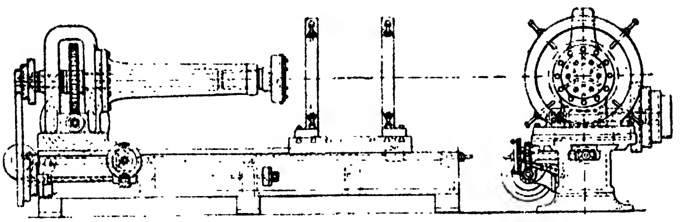


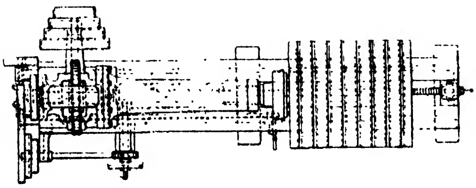
61. LOCOMOTIVE CYLINDER BORING MACHINE
(Newton Machine Tool Works, Philadelphia)

Slot-drilling Machines. *Slot-drilling* machines are used for cutting key and cottar-ways with a revolving drill-like tool having a flat end. Traverse has to be imparted to the shaft or spindle being tooled or to the drill. In the example [60] the spindle is carried in bearings in a sliding saddle, moved to and fro across the head by a screw driven from belts and gears. An automatic trip device, operated through the rod seen immediately below the driving belt, throws over reversing clutches when the saddle strikes a dog on the rod, the length of travel depending therefore on the position of the dogs on each side. The spindle is rotated by a belt which passes over pulleys at each end of the head, and is given a half-twist to lap round the spindle pulley, the longitudinal position of the latter not affecting the belt drive. A self-acting vertical feed of 2 in. is given to the spindle in order that keyways may be gradually finished to the required depth, the feed taking place gradually a little after each traverse. The table on the front of the column may be moved up or down, and across, to bring work into position. If shafts are



59. 16-SPINDLE MULTIPLE DRILL





62. SNOUT BORING MACHINE

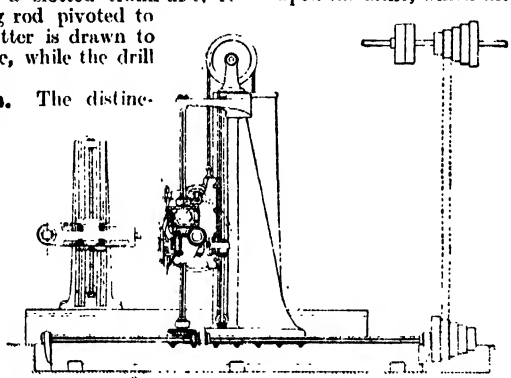
being handled, they are set in vee blocks, and held with clamps. The capacity of the machine is for slots 1 in. wide by 20 in. long.

In those machines which have a traversing table, instead of moving the spindle the motion is produced by gears driving a slotted crank-disc, reciprocating a connecting rod pivoted to the table, so that the latter is drawn to and fro at a suitable rate, while the drill merely rotates.

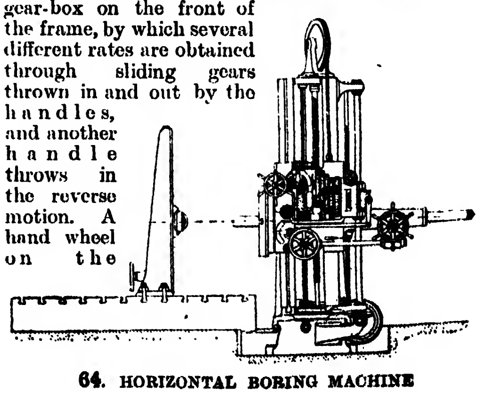
Boring Machines. The distinction between drilling machines and boring machines is obvious on glancing at the respective operations which they perform. Drilling is done with tools supported and driven from one end only; boring, with bars supported at two or more locations. Drilling originates holes, boring enlarges them. This classification is broadly correct, but it is hard to draw the line sometimes in stating what is boring, and what is not. As drilling machines are constructed in both vertical and horizontal forms, so boring machines are found in both types, but the horizontal predominates. This is because the length of holes to be bored is often considerable, and it would be difficult to operate the machines and watch the progress of boring if the spindle and work were upright, to say nothing of the awkwardness of the design.

There are two main classes of boring machines, those in which the boring tools are travelled, and those in which the motion is given to the work, the former constituting the majority. It is more convenient usually to slide a comparatively light bar through bearings than to traverse a casting or forging upon a table, especially from the point of view of setting and adjusting for the cut. When the boring tools are fed along, they may be either fixed in a bar which travels bodily or in a head that slides upon the stationary bar. The latter method is adopted for the heavier machines and for boring in the lathe, the bar running in bearings or between point centres. The difference in these designs is one of relative end motion; if a bar slides, it must be held in bearings, and must have sufficient length to carry the tools through the bore, plus a considerable overhang to remain in the bearings. But if a head is slid along the bar the latter need only be slightly longer than the work. Bars which slide are shown on page 4263 [36], and the sliding-head type resembles E and F in that figure, but with the addition of a screw sunk in the bar, and driving a nut screwed to the head. The screw runs in bearings at the bar ends, and is revolved by a *star wheel*, which strikes a pin placed on the machine each time it comes round, and so gives the screw a partial rotation. A regular instead of *intermittent* feed may be imparted by the use of *differential gears*. These comprise a train of spur wheels driving from the bar through intermediates and back again to the screw. One wheel has one or two teeth less than the other wheels, so that the screw is slowly revolved by the result of the different ratios. These *self-acting* bars are employed in both horizontal and vertical machines, the latter for heavy cylinder boring, which is done best when the cylinders stand on end.

Machines of the sliding-bar type are modelled upon the lathe, which they somewhat resemble, with the difference that the slide-rest is of rising and falling type, to bring the work into correct position. The area of this rest is large, and it is tee-slotted for bolts. The headstock has belt-cones and back gears, and drives the bar at varying rates by keys fitting in splines running down the bar, so that the latter may slide while still revolving. The feeding is effected from an extension arm at the rear of the head; it has a bearing encircling the bar and moving it backward or forward, this bearing being racked along the top of the arm either by hand or self-actingly. The bearing is clamped to the bar or released from it by set-screws. The feeding of the bearing is from the headstock, through gears driving into a gear-box on the front of the frame, by which several different rates are obtained through sliding gears thrown in and out by the handles, and another handle throws in the reverse motion. A hand wheel on the



63. HORIZONTAL BORING MACHINE



64. HORIZONTAL BORING MACHINE

sliding bearing racks the latter along rapidly, for adjustments. The table of the machine slides upon the vertical face of the frame, and is also supported by an arched frame or *yoke* at the other end, and held to it by bolts. The table is raised and lowered by two large square-threaded screws resting in sockets underneath it, and passing through nuts which are formed as worm wheels, and rotated by a shaft lying along the machine base, so that the screws turn simultaneously.

The shaft is rotated by hand, with a ratchet handle on the end, or by a belt pulley. A sliding table moves on the main table by screw and crank handle, and a cross slide is mounted above, to set the work transversely, or to set for boring a couple of holes one after another in the same object. A further table of circular shape is also used for certain work which may require holes bored in it at various angles.

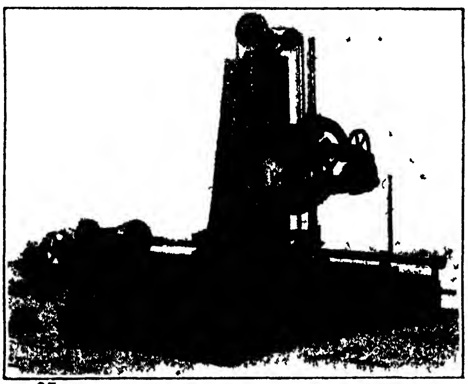
A *facing head* is employed for work that has end flanges or surfaces to be tooled at right angles to the bores. This consists of a slide rest fixed to the bar, and holding a turning tool. The slide is moved radially by its screw, which has a star wheel on its end, struck at each revolution by a fixed pin, thus feeding the slide little by little, until the flange has been finished across.

Fig. 61 represents a cylinder boring machine which possesses some resemblance to the foregoing, but has no arrangement for raising or lowering the table. The bar is rotated through cone pulley and gears, the largest of which is mounted on a sleeve encircling the bar. Two facing arms are seen, with star wheels.

Snout Boring Machine. A special type of machine, which, although the bar is supported at two locations, is enabled to bore a blank-ended hole, is the *snout* boring machine [62] (James Spencer & Co., Hollinwood).

It is useful for cylinders of various kinds which have no open end for a bar of sufficient size to pass through. The object is obtained here by carrying the bar or spindle out a good distance in a *snout* or tubular bearing, bolted on to the head, so that the cutting end is well supported, a taper neck allowing of take-up for wear. There are six boring tools in the head screwed on the end of the spindle, each clamped by two set-screws passing through a cover plate which is itself fastened on the head by countersunk screws. The drive is from a four-stepped cone pulley at the rear actuating a worm gearing with a large worm wheel on the spindle. The tail end of the latter has a three-stepped cone belted to another on a short shaft in front of the bed. This shaft drives a worm and wheel connected with a friction disc device, similar in action to that in 13, page 4913. From this mechanism a shaft goes at right angles into the interior of the bed, and drives mitre wheels actuating a longitudinal feed-screw. The feed only comes into operation when the wing-nuts on the friction disc are tightened up. There is also a rapid power adjustment of the saddle through the medium of mitre gears at the headstock end of the bed, driven by a belt-pulley seen at the far corner. A clutch between the mitres throws either into gear with the end mitre on the screw, and rotates the latter rapidly in either direction. The clutches are slid along by a short lever moved from a shaft passing through the bed to a handle, which is seen situated about midway along, where it is conveniently placed for the operator. The saddle is tee-slotted, and in the elevation and end view is shown with a couple of collars, provided with set-screws, by means of which some kinds of objects, such as liners and tubes, are gripped and centred for boring.

Multi-spindle Machines. Boring machines allied to these designs are constructed with two and more spindles, to finish work with several bores at one traverse, or several separate objects, such as bearings, axle-boxes, etc., on the one table. Other designs are made with two bars lying at right angles to each other, these are suited for such work as engine beds, with circular guides cast in, the guides and the crank-shaft bearings being bored without disturbing the setting. Machines for Corliss cylinders have a central bar for the bore, and four others for the valve bores, all working simultaneously.



65. HORIZONTAL BORING, DRILLING, AND MILLING MACHINE
(Niles Bement Pond Co)

A great deal of the work of the machine-shop is concerned with castings and forgings of awkward shapes, and often rather bulky, which have to be bored, faced, drilled and milled. A type of boring machine developed largely in recent years has the spindle adjustable up and down, an alternative to shifting the table. This gives the machine an increased range of capacity, and enables it to tackle the most awkward shapes. The work is not necessarily confined to boring, but the spindle is adapted to hold drills, facing tools, and milling cutters, and tapping is also done sometimes. The work remains bolted to the table or base plate. Figs. 63 and 64 give an example which is fairly representative of the class. It has a column, travelled along a narrow bed, in front of which lies a broad plate, well supplied with tee-slots, by which the work is bolted down. The bar of the machine is driven through gears connected up from horizontal and vertical shafts, actuated primarily from a five-stepped cone at one end of the narrow bed. Self-acting feeds are given through a set of nest gears, seen in 64, with reverse mitres, as well as hand movements. The column travels along its bed, and the spindle saddle feeds up and down the face of the column, being balanced with a rope and weight, the latter going within the column. When the bar projects to a considerable distance, the *out-board* steady seen on the large work-plate is brought into use. It is bolted down, and the horizontal slotted arm adjusted to coincide with the boring bar, which runs in the bushed end. Fig. 65 gives a view of a machine which presents the same features as the last type shown. There is a platform at the side of the spindle, on which the attendant stands, and if necessary travels with the column.

Continued

Group 24

POWER

1

Following Physics from page 4884

THE CHIEF SOURCES OF POWER

Natural Sources of Power and their Values. Reserves to Draw Upon in the Future. Animal Power. Water Power and its Value. Wind Power

By F. L. RAWSON

THE word *power* is used in a variety of senses—political, mathematical, chemical, etc.—but it is employed here only in the physical relation, and then only in the general sense popularly attributed to it in connection with engineering matters. Strictly speaking, the engineer defines power as *the rate of doing work*—that is, it is measured by the number of units of energy generated, transmitted, or absorbed, as the case may be, per unit of time. Popular usage, however, has associated with the word the mechanical agency or means whereby work can be done or processes carried on which otherwise would require the expenditure of human labour.

The First Uses of Power. The use of power for relieving man of physical exertion dates from time immemorial. Who can tell, for instance, when sails were first employed for the propulsion of boats? Or when were oxen first used in ploughing, or horses and camels in locomotion? These are examples of the earliest applications of wind and animal power respectively to the service of man. Again, the use of windmills and water-wheels took its rise in the dawn of civilisation, and represented an immense stride forward, involving for the first time the use of mechanical gearing for the transmission of power. Both these agencies were probably first applied to the preparation of the food of man—the grinding of corn, which for countless ages had been accomplished by manual labour on a very small scale. In fact, all the types mentioned above relate to the more elementary needs of mankind, and are in use to this day. Next come water-lifting and irrigation, first performed with the aid of animal power in the crudest fashion, but later involving the invention of the pump, a most important advance. The famous screw of Archimedes was invented for raising water, and doubtless formed the germ from which have sprung all screws.

Development of Power Utilisation. The advance of civilisation led to an increasing demand for metals, and the necessity for removing water from the mines whence they were obtained compelled the adoption of mechanical pumping machinery, first driven by animal power, then by water power, which was developed to a remarkably high degree of perfection for those days; and it was in this connection that the greatest advance in the development and utilisation of power in the history of the world took place, for it was in the Cornish mine fields that the application of steam to mechanical power production took its origin. First devised by Newcomen, the steam engine was improved by James Watt to an astounding pitch of excellence and economy, considering that the field was almost virgin when he came upon the scene. Rapid progress was made, and the steam engine was quickly applied to locomotion by land and sea, to the driving of factories, the production of iron and steel, and other industrial purposes.

Efficiency in Methods and Machinery. With the continued development of power utilisation came a demand for greater efficiency in both methods and machinery. Improved means of generating and using power were devised, such as the modern turbine in place of the old water-wheel, the threshing machine instead of the flail, and so on. Entirely new types of prime movers were also brought forward, such as the gas engine, which, thanks to the experience gained in the design and manufacture of the steam engine, was enabled to make as much progress in ten years as the latter had made in fifty. The discovery made by B. H. Thwaite, that the waste gases from blast furnaces could be utilised directly in gas engines to far better advantage than by burning under boilers gave the construction of large gas engines an enormous impulse, and now these are made up to 5,000-horse power, though but a few years ago a 200-horse power gas engine was reckoned large.

The older agent, steam, however, has not yet been vanquished by the gas engine, for the development of the steam turbine, with which the name of the Hon. C. A. Parsons will for ever be associated, has brought about an engineering revolution. Although the turbine was not used for marine propulsion until 1897, it has already superseded the reciprocating engine to such an extent that the largest steamships in existence are being equipped solely with Parsons's turbines for their propulsion. It now remains for some genius only to solve the problem of the gas turbine in order that the acme of efficiency may be attained.

Newer Forms of Power. In quite a different direction, the remarkable progress which has been accomplished in the construction of small high-speed engines has rendered them available for propelling vehicles on the common roads, airships in the air, and launches on the water. These motors are operated as internal combustion engines, fed with petrol, alcohol, paraffin, etc. The use of alcohol is noteworthy, as it can be manufactured from potatoes and other organic substances, thus opening up a new and inexhaustible source of power from natural products.

Considerations of space forbid us to enlarge upon the many uses and sources of power in addition to those cited above. We can but mention the electric battery, so necessary in telegraphic and telephonic communication; the

high explosives, such as guncotton and cordite —the gun is nothing other than an internal-combustion engine of enormous power; the use of electricity in power transmission; the vast store of energy in every molecule of matter, which we know to exist but cannot as yet utilise.

Sources of Power and National Strength. An important step towards this end is now in progress in the shape of the numerous projects which have been brought forward for the distribution of power on a large scale from huge electric generating stations to the surrounding districts. By this means power can be generated on the most economical lines, and the noxious products derived from the combustion of coal will be dissipated in the air in places far from the abodes of men. In other countries, which are blessed with abundance of natural water power, but not with coal, similar undertakings have for years been in operation, with results of the greatest benefit to the nations concerned. In time we may be able to transmit power to great distances by means of high-tension currents, such as the Hertzian waves, the principal difficulty at present being the motor.

It is an error to suppose that power generated from falling water is necessarily cheaper than power derived from coal; very often it happens that the engineering works required to make the water power available are so costly that the power thus obtained is more expensive than that generated with steam or gas engines. Much depends upon the local conditions; where coal is plentiful and water power scarce, as in this country, or vice versâ, as in Switzerland and Italy, there is practically no choice. In the South of Russia petroleum is the most convenient and the cheapest source of power; in the United States natural gas is met with in addition to all the foregoing sources. For the propulsion of steamships only coal and oil are utilised, and for driving airships petrol motors have proved by far the best, on account of the light weight of the fuel and machinery. For operating railways, coal, oil, petrol, and electricity supplied from a fixed power station are available. Thus every form of power generation has its special advantages, and it is impossible to say in general that any one form is better than another each must be considered with reference to numerous external considerations.

The Resources of the Empire. Within the British Empire almost every known source of power is to be found. Canada possesses both coal and water power, and from the world-famed Falls of Niagara, as well as the Shawenegan Falls, hundreds of thousands of horse-power are being or are about to be developed. South Africa is similarly endowed; apart from the extensive coal deposits in Natal, the magnificent Victoria Falls of the Zambesi are estimated to yield on the average 1,000,000-horse power. Australia has coal; New Zealand coal and water power. India possesses both, and oil as well. Moreover, it has been estimated that if the coal supply of the world gave out, it would be easy to replace it with wood fuel, which could be grown more rapidly than it was consumed.

The motion of the tides represents an enormous source of power, but it is difficult to render it available for use; nevertheless, it is quite possible that in the future this inexhaustible store will be drawn upon The direct heat of the sun is also available for use in tropical countries, though the means of utilising it at present available are too costly to compete in many places with other sources of power. The greatest source of energy, the ether, up to the present has been little understood. Great advances have been made, however, during the last few years by those investigating the subject, and it is quite possible that in the future it may be used as the source of the power requisite on this globe. It will be seen, however, that as power is indispensable to civilisation, so it is available in one form or another in practically all countries, and will be till the end of time.

Animal Power. Although human labour does not strictly come within our definition of power, it may be interesting for the purpose of comparison to state that a man of average strength can exert a force of 30 lb. at a velocity of $1\frac{3}{4}$ miles an hour for 10 hours a day; or he can carry a weight of 1 cwt. 11 miles in a day. But human labour is costly, and though there are many kinds of work which can be performed only by manual labour, it is one of the fundamental principles of modern commercial economics that this shall be as far as possible avoided, by the substitution of animal or mechanical work.

By far the most useful animal is the horse, which, indeed, in this country is practically the only animal that is called upon to work, the ass being comparatively scarce, and the mule still more rarely met with. Horses have at times been called upon to perform a great variety of functions, but most of these have now been filled by machinery, and almost the only duties remaining to them are those of transport, either by carrying or by hauling a load, and certain agricultural operations which also involve haulage, such as ploughing and mowing. An ordinary horse can do the work of five men; it can carry a man 30 miles in a day; it can draw a loaded cart weighing a ton on a common road at three miles an hour for eight hours a day; in general, it can do 22,000 foot-pounds of work per minute for eight hours a day. An ox, walking at the rate of $1\frac{1}{4}$ miles an hour, can do work equivalent to 18,000 foot-pounds per minute, such as hauling a load of $1\frac{1}{2}$ tons (inclusive of the carriage) on a road; an elephant can carry a ton on its back all day, at the rate of 4 miles an hour.

Water Power. The earliest form of water-motor is the water-wheel, usually operated by the weight of the water; but this has become practically obsolete, the turbine having taken its place. The latter is a machine in which advantage is taken of the kinetic energy of the water as well as of its potential energy by using fixed blades or vanes to direct the flowing water upon moving blades, in such a way that the water leaves the turbine with the minimum velocity and practically at, or even below, the dead-water level. In cases where the water is derived in small quantity from a great height, or, as it is

called, under a great head of water, the whole of the work is done by virtue of the momentum of the water, which is allowed to issue from nozzles at an enormous velocity in jets which strike cups of peculiar shape fixed to the rim of a wheel. In either case, the efficiency attainable reaches 80 per cent., and the power is given off on the shaft, either by belt or other gearing, or direct to the driven machine.

The Two Factors in Water Power. Water power depends upon two factors—the quantity of water flowing per second, and the height of fall, or "head." The "horse-power" used in engineering is equal to 33,000 foot-pounds per minute, or 550 foot-pounds per second, and therefore the horse-power available from a given fall is calculated by the formula:

$$HP = G \times h \times 0{\cdot}0182,$$

where HP is the available horse-power,
G is the flow in gallons per second,
h is the head in feet, and
$0{\cdot}0182 = 10 \div 550.$

The head, h, may have any value from 1 to 2,000 ft. or more, but obviously, to obtain any great power from a very low fall necessitates the flow of an enormous quantity of water per second, and the turbine must be of correspondingly large size and cost. Hence, a fall of small volume but great head is far preferable to a low fall of great volume, on account of the small capital cost, not only of the turbines, but also of the hydraulic works which may be necessary to store up a sufficient quantity of water and to convey it from the dam to the turbine house. It will readily be understood that as the cost of attendance on a water-power plant is small, and other running costs, such as that of lubrication, small stores, etc., are of little importance, by far the largest items in the cost of power obtained from this source are those of interest and depreciation on the capital expended. The relative magnitude of the latter can be reduced by utilising the plant as continuously as possible, for in most cases the flow of water is continuous day and night, whether it is used or not; hence water power is utilised most advantageously in connection with industries which can, or must, be carried on without intermission, such as grinding corn, electro-chemistry, etc. It is largely used for driving electrical machinery for lighting, traction and power, and in some cases the power generated is transmitted over very great distances—exceeding 230 miles, as in California—and in enormous quantities.

The Immensity of Water Power. The most striking instance of this application of water power is to be found at Niagara in North America, where it is estimated that 1,000,000 tons of water fall in every hour from a height of 160 ft. Here, the largest electrical generators in the world are installed, each having an output of no less than 12,500-horse power. Several large concerns are at work, and the aggregate horse-power of the plant at work and projected amounts to over 1,000,000. Yet the appearance of the famous Falls is not likely to be less majestic and awe-inspiring than at present.

Another immense waterfall which is at this time attracting much attention is the Victoria Falls on the Zambesi River—a much higher fall, but less in quantity of water than that of Niagara. Even in the driest season the Victoria Falls will be able to supply half a million horse-power, and it is proposed to transmit a portion of this by electrical means more than 500 miles to the goldfields of the Witwatersrand.

The cost of energy derived from water power depends mainly on the extent of the works necessary to dam the river and convey the water in pipes or in open sluices to the site of the power station or factory, the magnitude and cost of these works being determined by the local configuration of the land and similar conditions. In some cases the cost is so great that it is cheaper to use steam or gas power; in others, as at Niagara, the cost is remarkably low—only 0·24d. per horse-power-hour.

Wind Power. The great drawback to the use of wind power is the extreme variability of the source. The velocity of the wind ranges from zero in a dead calm to 100 miles an hour in a hurricane, while windmills can generally be used only over the range between 7 and 30 miles an hour. It is true that the power is cheap, for the necessary plant is inexpensive and the wind costs nothing; whereas for the use of water power a considerable rental is often charged. Owing, however, to the fickleness of the source, wind power is generally utilised only in very small quantities, and for purposes which are not detrimentally affected by the occurrence of interruptions due to calms or storms. Thus windmills are often employed for pumping water into reservoirs for the supply of villages or farms, for driving agricultural machinery, for grinding corn, and for draining marshy land. Large numbers are so used in the Channel Islands. It is possible by using a dynamo and a battery of accumulators to obtain electric light and power on a small scale from the wind, but automatic apparatus is necessary to regulate the charging of the battery, and this materially adds to the cost of the plant.

The theory of wind power is in a very unsatisfactory condition, and it is difficult to reconcile the conflicting statements which are published by different authorities on the subject. H. R. Kempe states that a windmill with four sails, each 24 ft. long and 6 ft. wide, with wind at a velocity of 20 ft. per second, is estimated to give about 4-horse power. The modern aermotors are constructed with a large number of small blades forming a wheel, which is mounted in such a way that when the force of the wind increases the face of the wheel is automatically turned away from the direction of the wind, so as to lessen the driving power and to maintain a fairly constant speed. The power is transmitted by a shaft with bevel gearing to the ground from the wheel, which is usually carried on the top of a light steel framework 20 to 60 ft. high. A wheel 16 ft. in diameter, with 18 blades having a total sail area of 131·3 sq. ft., with a 12-mile wind, gave about 0·6 h.p.

Continued

OPEN-HEARTH STEEL

Martin, Siemens and Siemens-Martin Processes. Various Processes of Open-hearth Steel Manufacture. Steel Castings. Steel Rails

Group 14
METALS
9

Continued from page 4911

By A. H. HIORNS

THE manufacture of steel in the open-hearth regenerative furnace is becoming more and more popular, and very great strides have been made in recent years through the introduction of the tilting furnaces, as well as by the increasing size of the stationary furnaces. The invention of the open-hearth furnace and its accessories is due to Sir William Siemens, and the successful manufacture of good steel in it was first accomplished by Messrs. P. and E. Martin, who used steel scrap and pig iron, dissolving the scrap in the molten pig iron, thus diluting the impurities as well as partially removing them by oxidation. This was termed the *Martin process*. Siemens afterwards succeeded in desiliconising and decarburising pig iron, with or without scrap, by means of oxide of iron ore. At the present time both oxide of iron and scrap are used with the pig iron, forming the Siemens-Martin process. The original method was to work only with an acid lining, but now both acid and basic linings are used, as in the Bessemer process.

The Martin Process. The Martin process is conducted as follows. The first thing is to solidify the bottom, which has been carefully prepared with good silica sand, by melting a small charge of pig iron and adding siliceous material to form a fluid slag. When this is melted it is well rabbled about to wash the banks of the furnace and then tapped out as scrap. The next three or four heats are less than the full charges afterwards worked, and consist of pig iron and a little scrap, the latter being gradually increased till the furnace is in good working order. The materials may be charged cold, or the scrap may be first heated to redness in an auxiliary furnace. Grey hæmatite pig iron of good quality, preferably low in silicon and containing manganese, is desirable, but a proportion of good white or mottled iron may be added. The pig iron—from 15 per cent. to 20 per cent. of the charge—is first added and upon this is placed steel scrap.

When the charge is melted it may be kept in fusion, because the intensity of the oxidising action may be easily maintained. In order to hasten the operation the pig iron may be charged into the furnace in the liquid state, and speedily raised to a white heat. The malleable iron, previously made red-hot, is then added in lumps. With a neutral flame, No. 1 grey pig iron will dissolve nine times its weight of Bessemer scrap, while No. 3 will not dissolve more than four times its weight, and, when the flame is oxidising, considerably less. The oxide of iron, Fe_3O_4, formed by oxidation, reacts on the carbon of the pig iron, producing carbonic oxide, which, on escaping, agitates the bath of metal, and thus tends to make it uniform in composition. When the whole is melted a test is taken, and when the metal shows a proper fracture and toughness, as well as the right degree of decarburisation, it is run into a ladle and cast into ingot moulds, as in the Bessemer process. This method of working is possible only with the best pig iron, so that the usual plan is to decarburise completely, and then to add spiegeleisen or ferro-manganese. The latter containing more manganese than the former, a smaller quantity is required for deoxidation, and as, therefore, less carbon is added, a milder steel is produced.

A few minutes suffice to melt the manganese alloy, during which the metal is rabbled, or stirred, to mix it thoroughly, after which the metal is ready for teeming into the mould. The tapping is effected by driving a pointed iron bar through the tap-hole into the bath of metal, and on withdrawing the bar the metal flows out and is followed by the slag. When the slag begins to flow the spout is taken away, and it is allowed to flow into a space prepared for it in the front of the furnace, that remaining on the hearth being removed by tools introduced through the working doors, which are on the opposite side of the furnace.

The Siemens-Martin Process. The Siemens-Martin process is similar to the above in operation. Pig iron is first charged in, and the requisite amount of steel scrap added. The proportion of scrap varies in different localities, depending on the quality of the pig iron and of the scrap procurable. With good hæmatite pig iron, about 70 per cent. of scrap is used, but in other cases it may be as much as 80 per cent. Heavy scrap is preferred to light scrap, being more readily handled and less liable to oxidation during the melting. If much oxide be formed on the bed of the furnace, it corrodes the lining. For convenience in charging, the pig iron is generally broken up into half pigs, and these are charged by hand through the furnace door with the *peel*, so as to distribute the charge evenly over the entire bed. In large furnaces the charging is done through two or three doors by men working with a peel at each. When the charge is thoroughly melted, Spanish or African hæmatite is added in lumps at intervals for the decarburisation of the metal. In this way, during the working of a 10-ton charge, 30 cwt. to 35 cwt. of ore will be added, each addition being followed by a state of violent ebullition of the metal on the hearth. Samples of the metal are taken for testing the malleability and toughness, and when the requisite purity is attained, the metal is allowed to stand for a short time to clear itself of slag, and small quantities of limestone are added during the process if the covering of the slag be insufficient.

Spiegel or ferro-manganese, or a mixture of both, is added to remove oxygen and give the requisite amount of carbon. The duration of this process is longer than the scrap process, and the hearth is more strongly attacked by the ore.

When the charging is complete, the heating goes on for twenty minutes, when the valves are reversed, and so on till the charge is melted. On the addition of ore, the boil begins, caused by the evolution of carbonic oxide, due to the action of the oxide of iron on the carbon of the pig iron, and this continues till the iron is nearly decarburised. For dead soft steel, the carbon is reduced to 0·12 per cent., when the furnace is ready for tapping. Before tapping, it is usual to *pig back*, as it is termed, by adding a few half pigs to the bath of metal, so as to keep it well on the boil before the addition of the ferro-manganese. The operation requires about eight hours, and four hours for charging by hand and repairs.

After the charge has been tapped from the furnace, the tapping hole is made up with fire-clay and anthracite, and the bottom carefully examined for holes or cutting on the banks. These are repaired by spreading over them silica sand and glazing it in. It is then ready for the next charge.

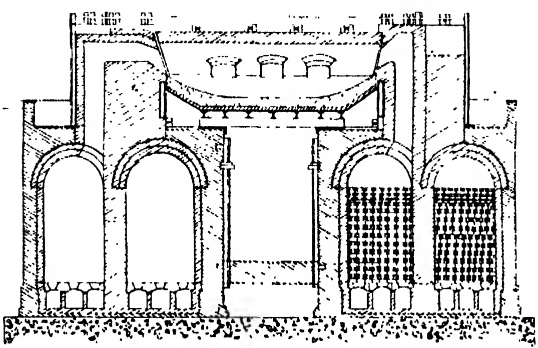
Acid Open-hearth Process. The acid open-hearth process does not remove phosphorus and sulphur from the iron, so that both increase relatively in the finished steel; hence the materials used must be low in phosphorus and sulphur. The silica should also be as low as possible, only sufficient, with the silica derived from the ore and furnace bottom, to form enough slag to cover the metal. The open-hearth process, like the Bessemer process, proceeds by first decarburising the bath of metal, and then by recarburising it by the addition of spiegeleisen, ferro-manganese, or other highly manganiferous alloy of iron, etc. The addition obviously introduces at the same time a small proportion of other impurities, such as sulphur, phosphorus, silicon, etc., into the steel; but the result is now minimised by the almost universal use of ferro-manganese as the recarburising agent, whereby a small weight of recarburising alloy is required for the introduction of sufficient manganese into the steel to prevent the red-shortness otherwise manifested by the metal, and to improve its malleability, without at the same time introducing too much carbon and such impurities as attend the larger amounts of spiegeleisen required. The use of ferro-manganese is specially necessary in the production of soft or mild steel. One advantage of the open hearth is that the steel can be quite dead melted, the process not being limited as to time, since the nature of the flame and the temperature of the furnace are so fully under control that the bath of fluid metal, after having been reduced to the lowest degree of carburisation required, may stand unaltered for any reasonable time, during which samples may be taken for testing, and additions of pig iron, wrought, scrap, spongy metal or iron ore, made so as to adjust it to the desired temper and quality; while spiegeleisen or ferro-manganese can be added in the solid condition in the required proportion immediately before casting, with the formation of a steel of which almost the exact composition is known beforehand.

In the open-hearth methods of producing steel the decarburisation and the separation of silicon and manganese from the pig iron of the charge do not appear to progress with the regularity which occurs in the Bessemer converter. During the first period of melting down of the charge in the Siemens furnace, the carbon, silicon, and manganese are more or less oxidised, so that at the end of this stage—the proportions vary with the temperature of the furnace—part of these elements have been removed. After the charge is melted down, however, the metal remains tranquil in the bath, undergoing little, if any, decarburisation, until the whole of the manganese has been oxidised, and the silicon in the metal has been reduced to about 0·02 per cent. This condition is obtained in from three to four hours, after which the bath of metal begins to boil from the escape of carbonic oxide resulting from the oxidation of carbon, and this state continues till the carbon is reduced to about 0·1 per cent., or less, at which point the bath again becomes tranquil, and the slag, which was, thirty minutes previously, of a brownish colour, begins to blacken, owing to the slight oxidation of iron.

The oxidation of the metal after melting depends on the composition of the slag and the temperature of the furnace. The variation in silica and oxide of iron directly after melting and just before tapping is comparatively small, but the amount of oxide of iron increases after the addition of the ore. This, however, is soon equalised by the taking up of fresh silica from the lining of the hearth. If the slag be thin, due to a low silica content, the oxidation of silicon and manganese in the pig iron is comparatively rapid; but if the slag be thick, or highly siliceous, the silicon and manganese are not removed, and may actually be reduced from the slag and pass back into the metal. With a very siliceous pig iron, a rich gas, and rapid draught, the temperature gets too high, the carbon is oxidised in preference to the silicon, and the decarburised iron is too high in silicon. Hence, while it is essential to have sufficient heat to maintain a fluid bath of metal or slag, the temperature must be regulated so as not to exceed a certain limit.

Recarburisation of Iron. In the early days of the process, the successful recarburisation of iron with free carbon was found to be impossible, owing to the imperfect knowledge of the effect of temperature on the oxidation of carbon. Both liquid and gaseous carburising materials were tried, but with little success, and the workers had to fall back on spiegeleisen and ferro-manganese as carburisers. But these are far from pure substances, and introduce impurities into the iron. When the microscope began to be practically used in the examination of metals, it was found that manganese did not alloy so readily with iron as had been assumed,

and, if not thoroughly mixed with the iron, it had a tendency to segregate. This explained many mysteries in the curious fractures of steel, and the addition of manganese was reduced to the quantity required for deoxidation. The basic Bessemer process especially led to a product comparatively rich in oxygen on account of the after-blow; therefore a larger amount of manganese was required to remove it, and this manganese prevented the production of high carbon steel unless such manganese was left in the steel. Efforts were therefore made to recarburise the iron without the addition of manganese alloy. If the deoxidation were effected in part by spiegeleisen, and completed by the addition of aluminium, only mild steel could be produced. Darby then introduced the use of free carbon for this purpose. In adding the carbon there is no marked change in the other elements, and as the carbon is added to the charge in the ladle, there is no reduction of phosphorus from the slag.



39. SE OF SIEMENS OPEN ARTH FURNACE

Medium carbon steels are now readily made in an open-hearth furnace for many purposes, such as the manufacture of axles, guns, springs, tyres, armour plates, wires, steel castings of various kinds, and tools. The carbon may vary from 0·3 per cent. to 1·2 per cent. There are three distinct methods of making such steels in an open hearth:

1. To work the charge of pig iron until it has reached the desired amount of recarburisation, and then tap out.

2. To work the charge until it is completely decarburised, and add spiegeleisen or ferro-manganese for recarburising.

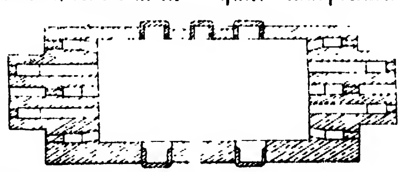
3. To work the charge as in the former case, and recarburise outside the furnace by the Darby or some similar process.

For steel with about 0·3 to 0·6 per cent. of carbon the first method is often adopted, but for best qualities the second method is preferred. The ferro-manganese may be added, either in the furnace, immediately before tapping, or to the metal as it runs into the ladle. For steels with 0·7 per cent. of carbon and upwards, satisfactory results cannot be obtained by simply working down to the desired carbon content, and then tapping. The third method, then, gives the best results. [See Harbord's "Steel," page 171.]

Mr. John Darby has advised a method of recarburisation by pouring iron through a tube perforated at the bottom and containing carbon, from which the carburised iron runs into the ladle. It was found that the absorption of carbon by the iron was so rapid that the lengthened time required by the above method of filtration was unnecessary. The next plan was to run into the filter vessel a stream of carbon particles at the same time as the metal was teemed into it. It was found that sufficient carburisation occurred during the teeming of the first third of the charge. The employment of the carburising vessel was afterwards found to be unnecessary, and now in similar processes it is customary to throw into the ladle at intervals a definite quantity of finely divided carbon. By this means considerable economy is effected, due to the saving of spiegeleisen or ferro-manganese. In some American works dry crushed coke, in paper bags, each holding about 50 lb., is thrown into the ladle with the decarburised metal, the first bag being thrown in as soon as the metal covers the bottom of the ladle. The accuracy of the metal will be understood when it is stated that out of twenty-four cases the carbon varied only 0·02 per cent. About half the carbon added is taken up by the iron.

The Siemens Open-hearth Furnace.

The Siemens open-hearth furnace [39 and 40] had originally only one working door, which was in the middle of one of its longer sides, but in the larger modern furnaces there are three doors. On the opposite side, and at the lowest portion of the hearth, is a tapping hole, and a channel through which metal is conducted for casting. The horizontal sectio is a rectangle with the corners removed. The hearth is composed of refractory sand, supported on an iron bottom, kept cool by a current of air, and it is repaired after each operation. The old type of furnace has the hearth built over the regenerators, using the regenerator arches to support the furnace. This method is now practically obsolete. The regenerators are kept well to each end, and the body of the furnace is carried on steel girders, quite independent of the regenerator arches, so that the air can circulate underneath, and in case of the metal breaking through the bottom there is no danger of its getting into the regenerators. The roof and walls of the furnace are lined with silica brick. The body of the furnace is encased in steel plates, well riveted together and strengthened by supports and tie-rods. The gas enters the furnace through two openings, termed the *ports*, and the air through three similar ports, all arranged side by side. The blocks containing these ports must be capable of resisting a high temperature and the consequent



40. PLAN OF SIEMENS OPEN-HEARTH FURNACE

expansions and counter actions, hence they are made with air-cooled hollow castings. The position of the ports is designed to give a perfect mixture of gas and air on entering the hearth, so as to ensure a complete and rapid combustion. The position of the ports depends to some extent on the contour of the roof. In some high-roofed furnaces, dome-shaped alternating arches, or gallery ports, are used for gas and air. It has been found with sulphurous fuels that the metal is less liable to take up sulphur during the melting when gallery ports are used. It was customary in former years to build the roof with a strong slope from each side to the centre, so as to deflect the flame on to the bath of metal, but it was found to be rapidly burnt away, and in all modern furnaces the best results are obtained with a fairly high roof, the inclination of the gas and air ports being sufficient to plunge the flame on to the metal.

The regenerators are chambers filled with a checker work of refractory brick, arranged so that brick and air spaces occur alternately. The air chambers are generally made longer than the gas chambers, but the chief thing is to have sufficient capacity. The chambers should be 15 ft. to 20 ft. deep, and the capacity of gas to air regenerators in the proportion of 1 to 1·4. In all regenerative gas furnaces much fine dust is carried over mechanically with the gases, and tends to choke up the spaces in the checker brickwork. In large furnaces especially, it is advisable to have a supplementary chamber between the ports and regenerators to serve as a dust-catcher.

Basic Open-hearth Process. The object of this process, like that of the basic Bessemer process, is the removal of phosphorus from the iron by means of a basic or neutral lining, and the addition of lime during the working. Several special furnaces have been devised for this purpose, but the ordinary furnace as used for the acid process gives equal if not better results.

A special type of furnace on the Batho principle was devised by Dick and Riley for use with the basic process. It has a circular or oval body, with a steel casing. It is placed on a platform supported by girders, and left entirely clear underneath, so that the bottom is kept cool and the lining better preserved. The four regenerators form four circular towers, and, instead of being situated below the bed of the furnace, are placed in pairs at opposite sides of the furnace. Each regenerator forms a separate structure, which is out of harm's way in case of the metal breaking out, and as it has only its own weight to carry, it cannot get out of shape. It is very desirable to regulate the amount of gases passing through the regenerators, in order to control the relative amounts of heat stored up in these chambers. The tendency is for the gas chambers to receive the largest amount of waste heat, whereas the air chamber should be the more highly heated of the two. The regulation is affected by the adoption of a new kind of disc valve.

The regenerators are 6 ft. 6 in. internal diameter, lined with 9-in. firebrick, and have outside casings of $\frac{3}{16}$th in. steel plates. The Batho method of arranging the flues has been adopted, the distinctive points of which are that the gas and air ways are brought up outside the furnace instead of inside, as in the ordinary Siemens furnace. In the latter form the expansion and contraction disturbs the brickwork, causing cracking, which leads to the mixing of the gas and air before entering the furnace ports. In the Batho type the external arrangement of the flues simplifies the furnace itself, reducing it to a simple box, which may be readily lined by ramming in material, or by brickwork. The ports are of the Hackney type, the air-port being placed vertically, or nearly so, above the gas-port, so that the two streams directly unite, and are not deflected as in the Siemens type.

The roof is dome-shaped, as in the Siemens radiative furnace, but it is not used for the purpose of radiating the heat of the flame, as the flame is thrown directly upon the material to be heated. The roof can be made movable, so as to introduce large pieces of scrap.

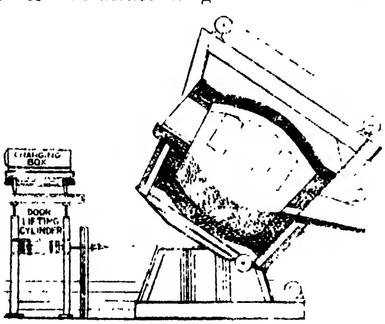
The roof is carried independently of the sides, and is built with silica bricks. The sides up to the top of the door and the gas-ports are of basic material. The acid section, however, does not rest upon the basic lining, a space being left between them, although acid and basic materials may touch provided one does not impose weight on the other. The basic lining is burnt dolomite mixed with tar, as in the basic Bessemer process.

Bertrand-Thiel Process. This consists of the use of two open-hearth furnaces used in conjunction, one termed the *primary*, and the other the *secondary* furnace. The upper, or primary furnace may be situated at a higher level than the secondary furnace, and is used for melting and partly refining common pig iron. The larger, or secondary furnace is placed at a lower level, in which the partly refined iron, together with all the scrap available and some ore are melted, and the iron completely refined. When working with a large proportion of scrap the furnace hearths need not be kept so deep—that is, they may have less cubic capacity for a given weight of charge than when working with pig iron alone, as in the latter case greater additions of lime and ore are necessary. Moreover, when pig iron alone is used, the charge boils up excessively, and may cause the slag to flow out of the working doors, so that some scrap is advisable to quiet down the metal. Silicon and manganese are practically eliminated in the first furnace, together with some phosphorus and carbon. About two-thirds of the carbon and one-third of the phosphorus are left, to be removed in the finishing furnace. It will be seen from the above remarks that if it be attempted to urge the rapidity of decarburisation in an ordinary single open-hearth furnace, the slag will rise so rapidly as to run out of the doors of the furnace. The greater rapidity of working in the duplex method is due to the fact of the impurities being slagged off in two stages, hence there is less slag present and more room for the metal. In the lower hearth the metal, which has been largely

freed from sand and slag forming elements, only causes a limited amount of slag to be produced.

In an ordinary open-hearth furnace the oxidation of the charge is chiefly confined to the upper part, where it is in contact with the overlying slag and the lumps of ore, but in the Bertrand-Thiel process the hot metal from the upper furnace is run on to white-hot scrap which has become strongly oxidised, so that the oxidising influence is both at the top and the bottom, and the metal is therefore more quickly purified. Moreover, at the high temperature of the Siemens furnace there is a violent reaction between the metalloids and the oxide of iron, and great internal heat is produced by their oxidation, which greatly assists in maintaining the temperature of the furnace. A basic lining appears to be necessary, and this lining in the preliminary furnace to a large extent contributes to the success of the process.

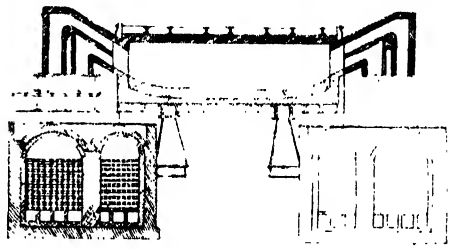
Talbot Process. This is a continuous open-hearth process conducted in a tilting furnace with a basic lining. The furnace is specially designed so that any quantity of slag and metal can be poured off at any period during the working of the charge. The method of working as explained by the inventor is as follows. The pig iron used has the composition—carbon, 3·76; silicon, 1·0; sulphur, 0·06; phosphorus, 0·90; and manganese, 0·40 per cent. This is melted in a cupola. Suppose the furnace to be charged on a Sunday night with 50 per cent. molten cupola metal and 50 per cent. scrap. This is worked in the usual way for steel. When the charge is finished, about one-third - 20 tons - is poured off into the ladle and cast into ingots. No slag is run off with this portion of the steel. Oxide of iron in the finely-divided state is then thrown on to the slag, and as soon as it is melted about 20 tons of cupola metal are run in to replace the steel tapped off. An immediate very active reaction takes place, during the continuance of which the gas is cut off from the



42. WELLMAN FURNACE - CROSS SECTION

furnace. Carbonic oxide is copiously evolved, and after the boil has been on for 15 minutes the slag is poured off, and the bath of metal worked into finished steel by the help of fresh additions of iron ore and lime. Another 20 tons are again tapped off, and another similar quantity of cupola metal added as before. These operations are continued for a week, and the furnace completely emptied on Saturday.

The Wellman furnace used in the Talbot process [41 and 42] is a long, horizontal chamber, resting on the pair of racks, and rolling on them by means of the segments of an enormous pinion. The rolling motion is given to it by large, nearly vertical, hydraulic cylinders, and when tapping, the furnace is tilted forwards [42] so as to depress the tapping spout, through which the metal is poured. The rolling surfaces are



41. WELLMAN FURNACE - LONGITUDINAL SECTION

provided with rack work, which keeps the furnace parallel without supporting any of its weight. In order to tilt the furnace, water is admitted to the top of the cylinder. The gas and air ports are of novel construction. The two passages leading from the regenerators and the ports terminate in two water-troughs on the level of the charging floor. The brickwork of the ports is enclosed in a metal cage, but instead of being fixed it moves on flanged wheels running on rails, which enable it to be moved a few inches to and from the furnace end. When melting is in progress the ports are moved up to the surface, so that the face plates are in contact. When ready to pour, the ports are moved away. A special kind of ladle is also used, attached to the front of the tapping hole, and forming part of the structure. This ladle has two pouring holes and stoppers. When the furnace is tilted for pouring, the metal and slag flow into the ladle and stand at the same level as the metal in the furnace.

Trains of casting bogies, each containing two moulds, are then brought under the teeming holes of the ladle, and two moulds can be filled simultaneously. The regenerative chambers are arranged in pairs at each end of the furnace, and extend under the charging platform. The furnace top, side, and outer layer of the bottom are lined with silica and magnesite bricks. The bottom is made with magnesite. The air-reversing valves are of the usual butterfly pattern, and the gas valves consist of two mushroom valves. Both valves and seats are water-cooled. There are three charging doors, operated by pneumatic cylinders through wire ropes, the leads being so arranged that the doors are kept closed while the furnace is being tilted.

Metal Mixer. Many attempts have been made to use the liquid cast iron direct from the blast furnace for charging the Bessemer converter and the open hearth, but owing to irregularity in composition this has not been successful. If, however, the tappings from several blast furnaces are mixed together in a special receiver, the irregularities are neutralised, a certain

amount of purification takes place, and a large mass of a fairly uniform composition is obtained. The mixer may be of various shapes, but it is usually made of wrought iron or steel plates, lined with firebrick. It is mounted on trunnions and tilted by powerful mechanical gearing. In some works the mixer is of a semi-cylindrical form with hemispherical ends and an arched roof. It rests on rocker bands, and is tilted by a ram at one end. In other works the tilting open-hearth furnace is used simply as a mixer.

Charging Machines. One of the defects of an ordinary open-hearth furnace is the great amount of time and labour absorbed in charging the furnace by hand, and this has led to the introduction of machines for this purpose. The first machines were worked by hydraulic power, but these have been replaced by electrically-driven machines, of which that of Wellman is the most largely used. The materials are put into iron boxes [42], each holding 1 ton, which are picked up by the machine, pushed into the furnace, emptied, and withdrawn, the whole operation taking one minute, so that 50 tons can be charged into the furnace in about one hour.

Casting of Steel. In order to get sound, forgeable ingots of steel, great care is necessary to avoid blowholes, segregation, and piping. For this purpose a *dead melt* is necessary that is, to finish with a good, thick, clean, non-oxidising slag, which must be at the same time fairly fluid, to prevent it entangling some of the metal.

Fluor-spar added to the metal in the ladle gives good results. The gases in steel are principally hydrogen, nitrogen, and carbonic oxide, and these are likely to increase with the rising temperature. The presence of silicon and manganese tends to keep these gases in solution, and thus to prevent unsoundness. Aluminium is generally added to the metal in the ladle for the same purpose. The amount of silicon, manganese, or aluminium should be limited to the quantity required for absorbing the gases, otherwise the excess alloys with the steel and injures its qualities as well as tending to promote segregation. A steel casting is very liable to have internal stresses, caused by unequal contraction on cooling. The amount of shrinkage varies from 1·5 per cent. to 2 per cent., according to the composition and temperature of the metal. The softer and hotter the metal the greater the shrinkage.

Annealing of steel castings is very important, in order to remove the stresses set up in solidifying, and thus to toughen the metal. The proper annealing of large castings takes nearly a week. Different articles require different amounts of carbon. Steel for pinions and hammer dies requires 0·6 per cent. of carbon; miscellaneous gearing, from 0·4 per cent. to 0·6 per cent.; general machinery castings, less than 0·4 per cent.; and castings subject to great shock should not contain more than 0·2 per cent. Hulls and gun-carriages contain from 0·2 to 0·3 per cent. of carbon. Steel castings to stand the same stress as iron need only to be two-thirds as heavy if they are large. Steel is now taking the place of iron in gearing, hydraulic cylinders, engine cross heads, pistons, rolls, spindles, coupling boxes, hammer heads, dies and castings for ships.

Treatment of Steel Ingots. Steel is not piled like iron for reheating, but cast into ingots of the proper size for the production of the required bar, plate, rail, etc. The hot ingots are usually conveyed from the moulds to a reheating furnace, and were formerly extended by the steam hammer before rolling; but this is now considered objectionable, and they are therefore passed directly through the *cogging* or roughing rolls, then reheated and rolled in the finishing rolls to the required section. For small rails, the blooms after cogging may be finished right off without reheating, being rolled in long lengths and then cut into rails of the required length by a circular saw. This reduces the amount of waste from the crop ends, as a fewer number of rough ends require to be cut off than when the rails are made in short lengths.

Soaking Pits. Instead of using a reheating furnace the sensible heat of the ingots may be utilised by placing them in hot pits built of masonry. The ingot of steel is removed from the mould as soon as it is sufficiently solidified, then placed in the hot pit and closely covered. By this means the heat given out by the metal is absorbed and stored up in the brickwork. In about an hour the ingot will be at a uniform temperature throughout, and sufficiently hot for rolling. During the soaking process a quantity of gases is liberated from the metal, consisting of hydrogen, nitrogen, carbonic oxide, etc., thus excluding the air and preventing oxidation. If the brickwork becomes overheated, it may be cooled by dropping in some coal, when the surplus heat is absorbed in decomposing the coal and in volatilising the products. Considerable economy is claimed for this mode of working, as the loss of metal by oxidation during reheating, together with the expenditure of fuel, is largely avoided.

If, however, the output be insufficient to keep the pits occupied, and considerable intervals of time elapse between the heats, the pits lose too much heat, and the ingots get cold. In such a case the pits are generally heated by gas.

Steel Rails. The essential properties in a rail are hardness and toughness, which do not generally go together. If the metal is not hard enough the wear will be too rapid, due to the constant abrasion to which it is subjected, and if too hard it is liable to be brittle and fractured by the sudden shocks which occur by trains running at high speeds over it. However, rails are now made harder (that is, higher in carbon) than formerly. A medium hardness is therefore best, as it gives a good life to the rail without the great liability to crack which harder steels possess. In order to compensate for the increased brittleness of the harder rails now in use, the weight has been increased from 56 lb. or 80 lb. to 84 lb. or 100 lb. per yard. The smaller figures are for rails for small lines, and the higher figures for rails for main lines.

Defects of Rails. One of the chief causes of brittleness in rails is the presence of too much phosphorus in the steel. Phosphorus generally raises the elastic limit, and thus the elastic ratio, which is an index of brittleness. An illustration of the vagaries of phosphorus in steel rails may be given in the case of weld-iron rails, which may have as much as 0·45 per cent. of phosphorus and yet stand a severe impact test without breaking, while steel rails with 0·3 to 0·4 per cent. of carbon and 0·15 per cent. of phosphorus are liable to break with a drop test of one ton falling through 6 in., so that anything above 0·1 per cent. of phosphorus is dangerous. In fact, the behaviour of phosphorus is so capricious that it is better absent altogether. Silicon is another element which tends to promote brittleness, and this should, therefore, be low. The higher wheel-loads now used on our large railways require that the rails should possess greater hardness, or the ends are liable to be crushed. The carbon is now increased to 0·5 per cent., the manganese to 1 per cent., the silicon to 0·1 per cent., and the phosphorus below 0·1 per cent. If the carbon be increased to 0·6 per cent., as in the case of some American rails, the phosphorus and silicon must be present only in minute quantities, or the safety of the rails will be dangerously impaired. Mr. Sandberg, rail inspector of the Swedish State railways, found that 80-lb. rails with 0·6 per cent. of carbon flew into pieces with less than half the specified *tup test*, while those with 0·45 per cent. stood the test of a drop of one ton falling from a height of 20 ft. Sir Lowthian Bell considers that the fracture of rails is chiefly due to mechanical causes rather than to chemical composition.

Nickel Steel Rails. Nickel steel is now being used for rails in America with excellent results. The following table, by P. H. Dudley, gives the chemical composition of the rails furnished by the Carnegie Steel Company, which were made by the open-hearth and Bessemer processes as indicated:

Name.	Open Hearth.	Bessemer.	Bessemer.	Bessemer
Nickel ..	3·52	3·22	3·50	3·40
Carbon ..	0·33	0·50	0·52	0·40
Silicon ..	0·05	0·13	0	0·11
Manganese ..	0·80	1·00	0	0·79
Phosphorus	0·14	0·09	0	0·09
Sulphur ..	0·02	0·03	0	0·04

The wear of these rails was very satisfactory. A report stated that since they were laid they had outworn two or three ordinary rails, and were then only beginning to show signs of wear. Some of the rails were, however, too hard, and in some breakages had occurred.

There are several distinct forms of wear and deformation of rails which must be due to the physical and mechanical properties:

1. Surface wear of the heads, due to the rolling loads. Surface wear from adhesion of the engines which draw the trains. Surface wear due to the application of breaks to retard or stop the trains. Surface wear due to sanding of the rails.
2. Oxidation of the surface of the rails.
3. Wear of the base of the rails on the cross-ties and under the spikes.
4. Wear and oxidation of the metal of the heads and bases of the rails at the fishing angles with the splice bars.
5. Wear and deformation at the joints.
6. Wear of the surface due to gradients, abrasion due to curvature, and distortion due to hollow wheel treads.
7. Large shearing stresses in the web of the rails, due to the rails riding the bolts.

So far as rails are concerned, the advantage of open-hearth steel over Bessemer steel has not yet been definitely proved, but whatever steel is used care must be exercised in making it, in pouring the ingots, in their handling and heating, and in the rolling and straightening of the rails. The new method of rolling has a tendency to prevent that care and supervision being exercised which was formerly bestowed when rails were made shorter and lighter.

Testing Rails. A rail, being practically subjected to a succession of blows in practice, is generally tested by a drop test. This consists of the weight of one ton falling through the distance of 15 ft. for a light rail, and 20 ft. for a heavy rail. For light railways in this country a rail weighing 56 lb. per yard is specified by the Board of Trade, a maximum load of 10 tons on the axle, and a maximum speed of 25 miles per hour. In order to test a rail for sufficient hardness, a short piece is laid on bearings about 3 ft. apart and the centre loaded with a weight of 10 tons to 20 tons, according to the weight of the section, under which the rail must show no appreciable permanent set, and there should be no undue deflection under a load of double this amount.

An American Rail-mill. A modern American rail-mill is arranged three rolls high, and consists of three or four separate mills, each driven by its own engine. This three-high system admits of two pieces being rolled in a stand of rolls simultaneously, and in such mills the grooves open upwards and downwards alternately, so that the rail does not need to be turned upside down between each pass, as in the reversing rolls. The hot ingots of steel as they come from the heating furnace or soaking pit are first passed through the blooming or roughing rolls. Here the steel receives a rough shape, and is then conveyed to the shears and cut into two pieces, one being used for a small rail, and the other for two larger ones. The large pieces are reheated, and pass to the finishing rolls, where the bars are made into finished rails. Before the final rolling the rail is taken to a cooling table, where it is allowed to remain until it has cooled down to a certain temperature (about 870° C.). This gives a fine grain

The smaller pieces to be converted into small rails are reheated in a furnace, and when sufficiently hot are passed in succession through three sets of rolls, each three high. The finished rails are cut into lengths 30 ft. long.

Continued

REFUSE DESTRUCTION

Collection and Disposal of House Refuse. Construction and Working of Refuse Destructors. Cost of Installation. Value of Residue

By A. TAYLOR ALLEN

THE composition of house refuse varies greatly with the town, the quarter, and the season, on account of the kind of combustible employed in the district. It consists of legitimate household waste of every kind which can be thrown into a dry receptacle, such as ashes, cinders, house sweepings, vegetable refuse, broken crockery and glass, bottles, waste paper, rags, worn mats, pieces of carpet, and cans. In addition to these, a vast number of other things find their way into the family dust-bin, through carelessness and extravagance. It is estimated that a thousand persons produce annually 350 tons.

Sanitary Science. The preservation of health has always engaged serious attention, and while all branches of hygiene have shared in the gigantic progress of modern times, probably the greatest advances have been effected in sanitary science. The cleanliness of modern cities, compared with the filthy habitations of a time not so very long remote, has had a tremendous effect on the mortality attending epidemic diseases, and if further proof were needed of the nearly complete security obtained in this manner, it is to be found in the history of the Jews. The Mosaic laws contained elaborate directions for health-preservation by scrupulous attention to cleanliness, and it is a remarkable fact that the Jews, throughout the whole of their existence, have enjoyed a wonderful immunity from diseases of the epidemic type, the only exceptions being at times when they have relaxed their vigilance in preventing near dwelling-places that continuous deposition of organic matter which is so productive of disease.

The second half of the nineteenth century brought forth numerous changes in the methods of freeing towns from obnoxious matters. One favourite procedure that has had to give way to latter-day ideas was that of filling up disused clay or gravel pits with the collected refuse. On the top of the decaying matter a layer of soil used to be put, and, in a few years, streets of houses sprung up on the sites of the old pits.

The law relating to the collection of house refuse and the consideration of a system of collection affects every municipal authority. Under Sec. 42 Public Health Act, 1875, every local authority may undertake or contract for the removal of house refuse; and under Sec. 44 of the same Act, and under Sec. 26 Public Health (Amendment) Act, 1890, they may impose on occupiers of houses such duties as will facilitate the work of collection.

Refuse Disposal. Manuring by refuse does not produce immediate results; the destruction of the organic products by fermentation takes place slowly, and the assimilation of the manure is long in completion. The mixture of débris and all kinds of unscreened refuse brings on to arable land and meadows obnoxious articles, annoying to the farmers and dangerous to the animals that work or graze on the land. The employment, more and more recommended by agricultural schools, of chemical manures, whose absorption is rapid and easy, has led the farmers—and the care for public health which is now beginning to preoccupy even rural districts has compelled them—to remove farther and further from their houses the heaps of refuse which formerly did not trouble them, and which had too long been accumulating on the farms to the great detriment of the public health.

Until recent years it was the practice in a London suburb to mix the sewage sludge with the house refuse, after taking out the rougher materials, such as pots, bottles, etc. For some years this mixture was readily taken by the farmers in the neighbourhood, who paid a small sum per load for the material. Gradually, however, as farmers and arable land became scarce, and bricks and mortar took the place of corn, the difficulty of dealing with this material grew very rapidly.

Economic Difficulties. The little ground that was left in the neighbourhood upon which farm produce was formerly grown was taken up by market gardeners, who had no great love for this material, for, although the land may be somewhat heavy, cabbages and plants of that character are not benefited by cinders and ashes; consequently the authorities were compelled somewhat to alter their mode of mixing the material. Eventually the demand became so small that they had to look the difficulties of the case fairly in the face and endeavour to find a remedy. To dispose satisfactorily of the heterogeneous masses of matter recourse must be made to the greatest agent, *fire*, which is recognised as the right means of disposing of rubbish, which, unless promptly dealt with, is a grave danger to health. Defective appliances for burning garbage are, however, themselves a nuisance. A refuse destructor properly designed and constructed is the only known means of disposal which satisfies both sanitary and economical requirements.

The Refuse Destructor. The destructor should be of the best pattern, and should be designed and constructed by experienced hands. The material to be burnt is varied in character; sometimes dry and dusty, sometimes wet and foul, containing animal, vegetable, and mineral

matter. The destructor must be capable of burning thoroughly whatever comes, producing nothing from the chimney but perfectly harmless gases, and nothing from the clinkering floor but perfectly burnt and vitreous clinkers and ashes. For these objects we require (1) very high temperatures produced by forced draught; (2) flue arrangements which ensure that all gases are exposed to the highest temperatures; (3) means of arresting all dust in the flues so that it shall not escape up the chimney.

It is also necessary that the furnaces be constructed in the most durable manner, and with the best of labour and materials, so as to stand hard wear and tear. Further, the cost of labour in working must be reduced to a minimum, and the conditions of labour must be such as can be borne by self-respecting workmen.

Cremation of Refuse. There is nothing new in the treatment of refuse by cremation; it is a subject the sanitary importance of which has been recognised almost from time immemorial. Ancient history records that the purification of insanitary difficulties by fire was the mode practised by the Jews, Greeks, and Romans. It is interesting also to notice that among the antiquities of ancient Rome is a pillar bearing the inscription: "Take your refuse further, or you'll be fined." In Jewish history, too, we read that the valley of Gehenna or Tophet, where some of the Jews once sacrificed their children to Moloch, and which was subsequently regarded as a place of abomination, was made a receptacle for all the refuse of the city of Jerusalem, and that perpetual fires were kept burning in order to prevent pestilential nuisances.

As regards our modern English modes of disposal by fire, the practice and appliances employed to-day are the result of much experiment, and various furnaces and machines have from time to time been designed and patented.

Utilisation of Residue from Cremation. Although in practice the first consideration must always be the effectual clearance of house refuse so as to prevent it becoming a dangerous nuisance, the question of its utilisation must frequently occur. In a well-conducted refuse destructor, the residuum consists of ashes and hard clinkers.

The utilisation of the residuum is important as bearing upon the cost of the so-called "destruction" of the house refuse, which formerly has been treated as a waste product.

Refuse destructor clinker has been found to consist of 74 per cent. slag and other matter insoluble in hydrochloric acid. The portion soluble in hydrochloric acid consists of silicate of alumina, lime, and magnesia and iron, with a little sulphate and a considerable proportion of finely divided and diffused metallic iron.

In a well-conducted refuse destructor, the residue consists of a fire ash and a hard clinker, which is fused more or less together, according to the heat to which it has been subjected.

The clinker is used for making concrete, by being broken into suitable sizes and mixed with Portland cement in the usual manner, the foundations, walls, steps, and even buildings being constructed of this material. Another use to which the clinkers are almost universally put is that of mixing the clinker with lime, placing the mixture within a pug mill with water, and thus manufacturing lime mortar.

Owing to the porous nature of the material, the mortar thus made is extremely tenacious and hard when set. Mixed with Portland cement, the clinkers form good artificial stone, either in the form of flagging steps, window sills, door heads, pillar blocks, and a great variety of purposes. The sides and bottom of one of the swimming baths at Bristol are covered with a layer compounded of the residue from a refuse destructor.

There is a good opening for the making of concrete paving slabs from the fine clinkers, and they can be manufactured successfully by hand. Economical ratepayers may thus be able to derive gratification from the fact that ashes from their back yards may be laid down as slabs at their front doors.

Origin of Refuse Destructors. The problem of cremating refuse in specially-constructed furnaces was not seriously attacked much earlier than 1870, but as the tipping grounds near large towns became filled up it was obvious that some new and more sanitary method of disposal would have to be found. It had been the custom to make small bonfires on the tipping grounds, in which the more promising combustible materials were burnt; and, as the difficulty of disposal became more pressing, the burning of refuse in a closed furnace naturally suggested itself. The first attempt, made at Paddington in 1870, to burn house refuse in closed furnaces proved a failure, was discontinued, and the plant was soon pulled down, as it failed for want of draught, a defect which was attributed to the furnaces being below ground level. The object of a destructor is to convert city refuse into fixed and harmless products by means of combustion, and to change organic matter into innocuous forms of vapour, carbonic acid gas, and nitrogen, all of which are commonly found in atmospheric air.

The pioneer of the municipal refuse destructor had to combat and overcome ignorance and prejudice at a time when the standard of sanitation was a low one. He was offering an imperfect appliance, fated to be prolific of nuisance, a furnace primitive in design, and certain to cause offence. He could offer no asset, even in the modest form of a vitreous and marketable clinker, and he produced no power available for work.

Ordinary type furnaces, built mostly by dust contractors, were used in London and in the North some forty years ago, but they were unscientifically constructed, and not adapted to the proper combustion of refuse. It was consequently found necessary to use coal or other fuel with the collected refuse to ensure its cremation.

A Pioneer in Sanitary Science. To the late Mr. Alfred Fryer must be given the credit of solving the important question of how

to deal in a sanitary and satisfactory way with town's refuse. He recognised at once that to render such refuse innocuous, it must be burned, and burned at such a temperature that the residuum should consist only of the incombustible portion of the refuse, and that this residuum should be completely sterile; further, that the destruction by fire should be conducted so that the gaseous products were free from smell and from admixture with solid particles—this destruction by fire to be carried out without the addition of any fuel of higher calorific value. Mr. Fryer invented and designed the first furnaces put up in this country for destroying refuse. He termed one furnace a "cell," and he coined the word "destructor" to represent a plant consisting of one or any number of cells.

Types of Refuse Destructors. There are various types of refuse destructors. With a few exceptions, they all have this common feature. The furnaces or cells are strongly built of brick, with iron fittings, and the general building, surrounding and covering the destructor, is of brick, with roof supported on iron columns. The destructor is approached by an inclined roadway to the top or tipping platform, from 16 ft. to 18 ft. above the clinkering floor or ground level. In the centre of this platform is a series of feeding holes, or hoppers, into which the refuse is drawn and let down into the furnaces or cells below. The stokers standing on the clinkering floor, at the ground level, rake the refuse forward on to the grate or fire-bars, and once combustion is begun no fuel is required, there being sufficient combustible material in the refuse to keep the furnaces going. There is no storing of refuse, no more being taken to the destructor than it can burn as delivered. After burning, the refuse is reduced to about a third or fourth of its original weight, the residue being made up of fine ash, strong hard clinker, old tin, etc. But having passed through the fire, it is now powerless to do any harm, and it is not without its uses.

The destructor has now become very general throughout the country, and numerous furnaces of recent type are now either in course, or at the point, of erection, a destructor in large towns being regarded almost as an indispensable item in the list of municipal contrivances.

Construction of Modern Destructors. The first destructor was erected by Manlove, Alliott & Co., of Nottingham, about the year 1876 or 1877, at Water Street, Manchester, and consisted of two simple cells, which proved to be capable of meeting practically all the requirements laid down. It is even related that in this first destructor, sludge swept from the macadamised roads of Islington was burned with no other admixture than an equal part of the wet contents of the ashpits of Manchester, and no other inconvenience was felt at the destructor than a diminution of the amount of work the cells could perform.

Mr. Fryer's original cells form the basis of nearly all the different types of destructors since erected, and the essence of his first patent was—"Charging or supplying the refuse at the back, and drawing out the clinker, the residuum, at the front." In the cells or furnaces themselves, two processes are continually going on—namely, (1) combustion of the refuse on the fire grate, and (2) the drying of fresh refuse preparatory to its replacing the refuse in a state of active combustion.

Operation of the Destructor. The refuse having been collected, it is delivered on to a tipping platform, usually arranged at a higher level than the top of the cells. This tipping platform is reached by an inclined road. Two methods of feeding the furnaces may be adopted—hand feed, in which case the refuse is raked forward through the charging holes on the top of the furnaces, or a very valuable adjunct to a destructor, namely, Messrs. Boulnois & Brodie's patent refuse storing and charging apparatus. In either case the refuse gravitates downwards through the furnaces, emerging at a lower level as clinker and fine ash, and amounting to about 25 per cent. of the original weight.

The storing and charging apparatus consists of trucks running on rails on a second platform below the tipping platform. These trucks are divided into sections, the contents of each section forming a suitable charge for the furnaces. None of the refuse is handled by the attendants, and the operations are conducted with cleanliness and convenience. The trucks are moved by means of chains operated by winches on the platform above, being moved either over the charging door on the top of the furnaces, when the refuse is automatically discharged from the truck section immediately over the opening in suitable portion to constitute a charge, or withdrawn away from any chance of becoming heated till another charge is required. None of the refuse comes into contact with the heated surface of the destructor till it is actually delivered into the furnace, and the opening and closing of the charging doors is very quickly effected.

The "green" refuse fed into the furnace falls upon a sloping drying hearth at the rear, where the moisture contained in it is soon evaporated. It is then raked forward on to the firebars, there to undergo active combustion, the temperature in the furnace usually being over 2,000° F. The gases and fumes given off by the green refuse are made to pass over the hottest part of the fire, and are thus cremated.

The application of forced draught—or forced combustion—results in the increased efficiency of the destructor furnaces as refuse burners. It has been found most economical to apply the fan system of forced blast, by means of which some 10 to 12 tons of refuse may be burned per cell per day.

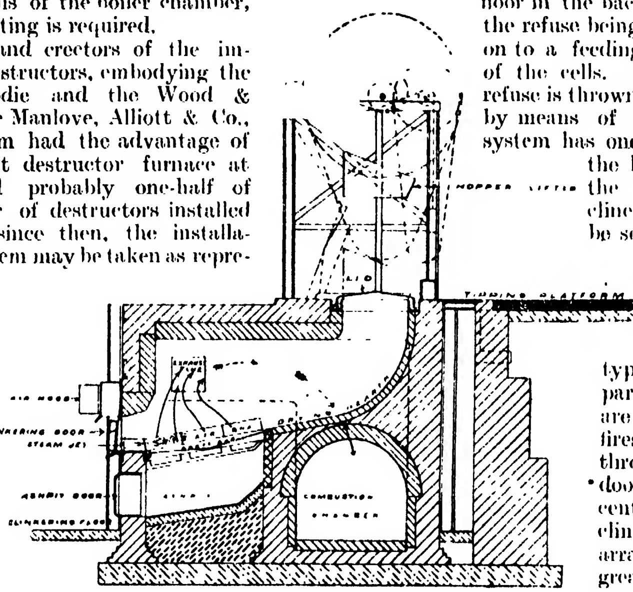
The "Wood and Brodie" Destructor. The "Wood and Brodie" combination of destructor cells and power plants consists of the sandwiching of a water-tube boiler between each pair of furnaces or cells, so that the hot gases pass directly into contact with the heating surface of the boiler. As two cells are always delivering the products of combustion to one boiler, one cell can be at its hottest and brightest condition by the time the other is ready for firing, the

temperature around the boiler tubes, as well as the steam production and pressure, being maintained practically uniform.

The foregoing combination is arranged as a " unit," each unit consisting of two cells and one boiler. The destructor cells as well as the boiler each have an alternative connection to the flue. One or both furnaces of the unit can therefore be used as simple refuse-burning furnaces when the boiler is shut down for any reason, and the boiler can be used as a coal-fired steam generator should this be desired. The boiler is suspended quite independent of the brickwork. It is thus free to expand and contract without affecting the brickwork in any way. The side walls of the cells form the walls of the boiler chamber, and no special seating is required.

The designers and erectors of the improved Fryer's destructors, embodying the Boulnois & Brodie and the Wood & Brodie patents are Manlove, Alliott & Co., Ltd. As this firm had the advantage of erecting the first destructor furnace at Manchester, and probably one-half of the entire number of destructors installed in this country since then, the installations put up by them may be taken as representing the most advanced practice.

Horsfall Furnaces. The following improvements have been patented by the Horsfall Company all over the world, and they are the chief features of distinction between the Horsfall and other furnaces.



1. SECTION OF CART-FED FURNACE

The first type of furnace illustrated—namely, the " cart-fed " [1], erected at Bromley and other places, is a great improvement from the point of view of economy in charging. The furnace is provided with a water-sealed lid of large size, which can be opened by means of a chained wheel actuated by hand. The feed-hole is large enough to take the whole of the contents of a four-wheeled van. This arrangement saves all the labour of charging the furnaces by hand, and it is also much more ready, as it frequently enables two tons of refuse to be shot into the furnace, and the lid closed again, within about half a minute.

The method of working is to have enough spare carts to store the refuse for the night, such carts being brought as required, and their contents shot into the furnace during the time when the collection is not going on. This system of direct charging has a sanitary advantage in the fact that it prevents any picking over of refuse, for the saving of tins, rags, and so forth.

The second type illustrated [2] is that at West Hartlepool, in which the furnaces are placed back-to-back, and the refuse is shot from the carts on to the deck forming the top of the furnaces; the deck, however, is kept cool by means of air ducts or conduits formed in the top of the furnaces. The refuse is then fed into the furnace by being pushed down through the charging opening. There is no lid to this type of furnace, but the refuse is simply trodden down into the feed-hole after the furnace is charged, and, owing to the peculiar shape of the feed opening, it closes the hole smoke-tight.

The third type [3] is the " back-fed " furnace as in use at Luton, Windsor, and many other places. This type of furnace is similar to the last except that the feeding is done through a vertical floor in the back of the furnace, the refuse being first of all tipped on to a feeding bin at the back of the cells. From there the refuse is thrown into the furnace by means of the shovel. This system has one advantage over the last described, in the fact that the inclined road need not be so long or high as for the " top-fed " furnace.

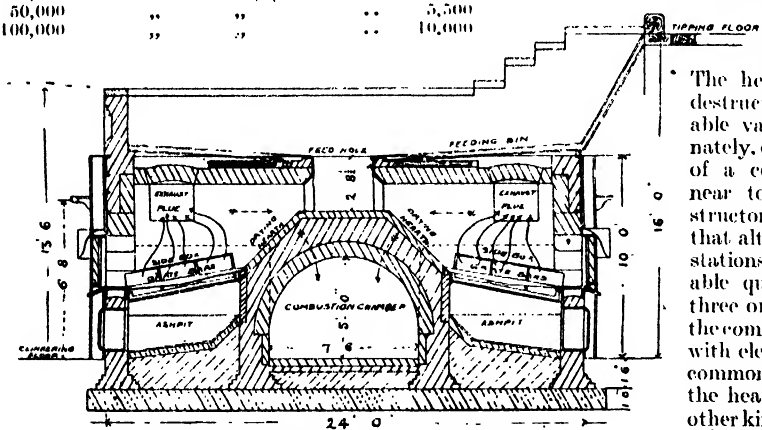
Similarity of Working. In all three types the working parts of the furnaces are very similar; the fires are trimmed through small rake doors fixed in the centre of the large clinkering doors, and arranged so that the greater part of the work can be done by the men without being exposed to the heat. The clinkering doors are opened only for the purpose of clinkering, which is done at intervals of about two hours. The furnaces in all cases are worked in strict rotation, so that there are never two freshly-charged fires at the same time. The furnaces are provided with forced draught, which may be obtained either by means of steam-jet blowers or fans. In either case the air is led first through cast-iron side boxes, which form the sides of the furnace for about 8 in. above the grate bars, and in passing through the upper part of these boxes the air is thoroughly warmed, being raised to about 400° F. before it enters the ashpit. Thus a hot blast is provided, the heat being abstracted from the clinker in the furnace. The boxes have the further great advantage that they prevent the clinker from sticking to the sides of the furnace and undermining the furnace hearth.

In all Horsfall plants the cells are completely separate, so that any one cell can be repaired without stopping the others. They are all provided with ample drying hearths over the main flue, so that the stuff is well dried before being dragged forward on to the fire.

The outlet for the products of combustion is in every case placed in the front high up over the hottest part of the fire. This arrangement causes all the fumes given off by the refuse in drying to be thoroughly cremated and scorched over the fire itself before they can possibly escape from the furnace. The products of combustion from all the furnaces mix in a combustion chamber or main flue situated below the drying hearth, and this flue is constantly maintained at a bright red heat, or about 2,000° F. By this means the possibility of smoke from the chimney shaft is prevented. It may be noted, however, that more frequently nuisance from the chimney shaft has been caused by fine dust carried in the gases than by smoke. To guard against this the Horsfall Company provide a *centrifugal dust-catcher* or *vortex chamber* into which the gases are led in such a manner that they revolve rapidly within the chamber before passing outwards to the chimney, thus throwing off the suspended dust by centrifugal force, the dust passing into a pocket arranged at the outside of the dust-catcher. This pocket is arranged so that it can be emptied without interrupting the process. By this means the whole of the suspended dust is extracted, and the chimney is frequently so clear that it is not possible to tell whether the plant is working or not.

Cost of Installation. The cost of destructor installations varies within very wide limits according to the arrangement of the plant and the adjuncts included. The sums mentioned below, however, may serve as a rough indication of the average cost of plants which have been erected within recent years :

Population.		£
5,000	With small boiler, etc.	650
10,000	,, ,, ...	1,250
25,000	Modern steam raising plant ..	3,000
50,000	,, ,, ..	5,500
100,000	,, ,, ..	10,000



2. SECTION OF BACK-TO-BACK TOP-FED FURNACE

These figures do not include any buildings or chimney, but represent the cost of plants contained inside the buildings. The cost of buildings, of course, varies very much, depending upon the style, ranging from the cost of a corrugated iron building to that of an ornamental structure in brick or stone, in harmony with surrounding buildings and having some pretensions to architectural beauty.

The engineering advisers of public bodies are concerned as to the cost per ton of destroying refuse in destructors. The following is a summary of 35 districts :

5 (*i.e.*, 14·3 per cent.) exceed 1s. per ton.

30 (*i.e.*, 85·7 per cent.) are under 1s. per ton.

As an example of the expenditure and profit arising from a refuse destructor installation, take a town of, say, 30,000 population, and assuming the quantity of refuse to be 250 tons per annum per thousand of population, and the destructor to work 300 days per annum, then :

$$\text{Population in M Tons } \frac{30 \times 250}{300 \text{ days}}$$

∴ = 25 tons of refuse per day.

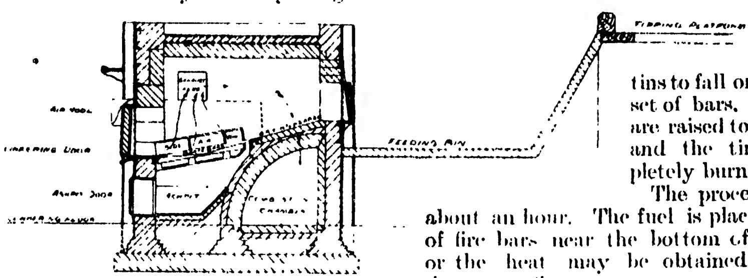
	s.	d.	£	s.	d.
Cost of destructor cells, boiler, etc, complete, say			2,950	0	0
Cost of buildings, chimney, etc., say			1,550	0	0
			£4,500	0	0
Labour, cost per ton of refuse destroyed, say	1	0			
Interest, sinking fund and maintenance, say	1	0			
Total cost per ton destroyed	2	0	= 750	0	0
			(per annum)		
Steam power raised (which may be supplied to, say, electric light or other power works) upon a low basis of 1 lb. of steam per lb. of refuse and 20 lb. of steam per I.H.P. 840,000 at ·29d.			1,015	0	0
Residue of clinker, for which there is a ready market, say, 25 per cent. 1,875 tons at 2s			187	10	0
			£1,202	10	0

Thus, an annual profit of £450 could be derived from a small, well-designed destructor installation.

Utilisation of Power Generated. The heat of the gases from destructors is of considerable value, but is, unfortunately, often lost through lack of a convenient application near to the site of the destructor. It is a curious fact that although electric-lighting stations demand a considerable quantity of power only three or four hours per diem, the combination of destructors with electricity stations is the commonest method of utilising the heat. There are, however, other kinds of municipal work that can absorb a fair proportion of the power available. Stone-breaking, crushing and screening the clinker from the destructors or grinding it into mortar, driving repairing shops, sawing, sewage and water-pumping, heating baths, wash-houses, and even schools, have been carried out in different places by means of the

steam from destructors. In many towns and cities the steam generated from the burning of refuse produces a very substantial income.

Many examples of excellent steam raising results obtained by plants arranged on the Wood & Brodie principle might be cited. At Liverpool, which was one of the first cities to see the possibilities of the destructor in the matter of supplying electric current, the Laverock Bank destructor is credited with producing from 60 to 80 units of electricity for every ton of refuse sent to the depôt, and that without the use of coal. At Cobb's quarry destructor, steam to the value of £1,700 was generated during 1902, this steam generating close upon a million and a quarter B. T. units of electricity and representing a value in electricity of about 1s. 8d. to 2s. for every ton of refuse sent to this destructor during that year. Something like 7,000,000 units of electricity—a very large proportion of the whole of the electric current generated by the Liverpool Corporation for tramway purposes — is generated by means of the refuse destructors at Liverpool.



3. SECTION OF BACK-FED FURNACE

At Nottingham it has been found that the actual production of electricity has amounted to over 70 B. T. units per ton of refuse over the working day, and this under everyday conditions.

As it is misleading to express the value of refuse in terms of B. T. units of electricity without taking into consideration the steaming powers of the boilers, the economical working of the engines, etc., it will perhaps be well to record an observation made in April last (1906) at the Partick destructor, where, on the basis of 30 lb. of steam per B. T. unit, over 127 B. T. units per ton of refuse burned were generated. To state this in another way: each ton of refuse coming into the works had an average value over the day of 127 B. T. units of electricity, assuming the engines to work with a consumption of 30 lb. of steam per unit.

At the Cambridge combined plant—which was the first of the Wood & Brodie system to be erected, and consequently may be looked upon as showing a good record of continuous working over a number of years—the steam is used to pump the whole of the sewage of the town, amounting, at times, to as much as 7,000,000 gallons per day, delivering it to a sewage farm 2½ miles away from the pumping station, house refuse being the only fuel. The saving effected in the coal bill at Cambridge by the combination amounts to over £1,000 per annum.

Recovering Solder. Swaine & Harrison's patent furnace has been designed to recover the tin and solder from the old cans that have been used for preserved meat, fish, fruit, etc. The furnace performs two operations, one melting off and collecting the solder, and the other burning the tin off the iron so as to leave scrap of marketable character. The method of working is very simple, and can easily be understood by a labourer of ordinary intelligence. The soldered tins are collected and tipped into the oven. In the course of three or four minutes the solder will be seen running out in a stream through the shoot which leads it into the receiver. The attendant moves a handle, which causes the tins to fall on the lower set of bars, where they are raised to a red heat and the tin is completely burnt off.

The process occupies about an hour. The fuel is placed on a set of fire bars near the bottom of the oven, or the heat may be obtained from the destructor flue.

Wages may be considered practically the only cost of working the furnaces, as the heat may be obtained from the combustion of rubbish.

The following figures give results from actual working:

	£	s.	d.
Eight batches per day (solder tins):			
Yielding 50 lb. solder per day		18	9
Yielding 12 cwt. iron		10	2
	1	8	11
Expenses (wages)		6	3
Clear profit per day	1	2	8
Ordinary tins from stock heap:			
Yielding 12 lb. solder per day		4	6
Yielding 14 cwt. iron		11	10½
		16	4½
Expenses (wages)		6	3
Clear profit per day		10	1½

The selling price of solder, of course, varies with the market. It has been disposed of at prices varying from 6d. to 8d. per lb., and is usually about two-thirds the market value of tin. The solder has undergone severe tests and has been proved to be of good quality. The scrap iron being perfectly freed from tin, always commands a market, but the figures given above are fixed on the sale of solder only. The scrap iron sells at from 10s. to 20s. per ton, and is, of course, of excellent quality. This patent can be embodied in the Horsfall destructor scheme.

REFUSE DESTRUCTION *concluded; followed by* HYDRAULICS

PRINTING

Branches of the Industry. Compositors. Readers. Stereotypers. Machine Men. Type and How it is Named and Measured. The Point System

By W. S. MURPHY

THOUGH the history of printing is replete with incidents of importance, and of a fascinating interest, it is with the vast printing industry of to-day that we propose to deal in these articles. We shall describe the most up-to-date methods of working, and shall illustrate some of the most recently invented machinery.

The Three Divisions of the Printing Trade. Like all great industries, printing has been broken into separate branches on the division-of-labour principle. The three main divisions are (1) Book Printing, (2) Commercial or Job Printing, (3) Newspaper Printing.

Mastery of a trade implies a knowledge of all its branches. Hence has arisen the need for technological instruction. Workshop practice imparts wage-earning dexterity in one branch and nothing more ; a knowledge of the general principles and character of the industry must be otherwise acquired.

Book printing is the oldest and most important branch of the industry. Nearly 6,000 new books are issued in the United Kingdom every year. In addition, most of the leading publishing firms produce large reprint editions of popular books and the works of standard authors every season, the numbers of which can only be approximately estimated. Expert opinion puts the annual issue of "sixpenny reprints" alone at eight million copies. Library reprints of the great authors have been produced in editions running up to tens of thousands. These figures represent a vast amount of work for the book-printer, and the market is capable of indefinite extension.

Commercial or job printing is the chief employment of small offices and of most country printers. A merchant wishes to intimate some new acquisition of stock to his customers, and, instead of writing, he draws up a circular and has it printed. Nearly all public intimations and business communications, which must be issued in numbers of copies, are the work of the commercial printer. He is the letter-writer, public crier, advertising and general business medium of the community. It is in this branch of the trade that artistic ability is specially required.

The Production of the Newspaper. Newspaper printing is rapidly becoming what may be called the machine-factory branch of the trade. Linotype, Monotype, and other type-setting machines are taking the place of the hand-setting compositor, and the great rotary web printing machines have already reduced the printing of newspapers to a series of operations automatically performed by machinery attended by a few workmen. So far from having lowered the status of the news workman, this revolution has given him a wider outlook and afforded him an opportunity of further using his intelligence.

Weekly and Monthly Magazines. Magazine printing stands midway between the book and news branches, covering, with periodicals, the whole interval. Some weekly and most monthly magazines are practically books, beautifully illustrated and carefully produced ; some periodicals have all the characteristics of newspapers, excepting the name and a slight difference of form. Printing, too, closely touches many other trades, such as lithography and bookbinding. The student would do well to look into the cognate industries, and he may turn to the instructions given on Lithography, Bookbinding, Engraving, and Typefounding in these volumes.

Not only has the printing industry divided itself into different branches, but the printing process itself has been broken up into four trades, more or less separate. In the old days the printer set up the type, and then corrected, imposed, stereotyped, and printed it. Now all these operations are performed by different sets of workmen, each specialising in his own craft. *Compositors*—including hand and machine—set up the type ; *readers* correct the errors of the compositors ; *stereotypers* take castings off the type ; *press men* or *machine men* print the work on the paper. As a wage-earner, the man must devote himself to one or other of these trades ; but as a craftsman he should be well acquainted with all four. The conditions of service of operatives in the printing industry are given in detail on page 2655.

What Type Is. Every letter of every printed word is a separate type. A type is a piece of metal a little under fifteen-sixteenths of an inch in height, the breadth and depth being determined mainly by the size and width of the letter. Because the impression, or printing, is taken on the top of the type, all type must be of the same height—that is, the same length of body. The metallic composition of type varies a good deal, each typefounder having his own recipe ; but, in general, it may be said that the main constituent is lead, with different proportions of antimony and tin to harden the metal. Here are some recipes used by leading founders:

25 lb. lead to 3 lb. mixed antimony and iron
55 per cent. lead, 22·7 antimony, 23·3 tin.
61·3 lead, 18·0 antimony, 20·7 tin.

An exquisite little piece of workmanship, this type, though so small, has many parts, each one of which is fashioned for a definite purpose. The letter cast on the top is called the *face ;* the slant of head and bottom of the letter is called the *bevel ;* the space of the body at top and bottom of the letter, the *beard* or *shoulders ;* the notches in the fore side of the body, the

nicks; the *groove* and *feet* are at the bottom. On the face the typefounder bestows his utmost care, for that is the type: but the other parts are also important. The bevel gives wearing strength to the letter, and the shoulders are spaces for the upward or downward strokes of ascending or descending letters.

Look at "d" and "y," for example. The upper stroke of "d" fills the top shoulder, and the downward curve of "y" occupies the bottom. By this arrangement the body of the type embraces every letter. In many books, and in most newspapers, the lines of type are set close together, but if the upward and downward strokes of the letters projected, that would be impossible. The letter "f," projecting as it does to the side, where no space is allowed, cannot be brought into proximity to "i," "f," and "l." For that reason "ff," "fi," "ffi," "fl," and "fll" are cast separately, and used as one letter.

The Fount. There are twenty-six letters in the English alphabet; but the language employs regularly 162 different letters or symbols, exclusive of fractional figures, and other signs not in common use. A complete set of these letters, in quantity sufficient for use, is called a *fount of type.* A fount of type may be small or large: it may consist of a few only of each letter, or run up to thousands of even the most obscure signs. Here is a representative fount:

Capitals—A B C D E F G H I J K L M N O P Q R S T U V W X Y Z Æ Œ.

Small Capitals—A B C D E F G H I J K L M N O P Q R S T U V W X Y Z Æ Œ

Lower Case—a b c d e f g h i j k l m n o p q r s t u v w x y z æ œ fi ff fl ffi ffl

Figures—1 2 3 4 5 6 7 8 9 0

Points— . , ; : ! ? ' - ( ) [ ] ¦ ... —

Accents—ä ë ï ö ü (diæresis)
á é í ó ú (acute)
à è ì ò ù (grave)
â ê î ô û (circumflex)
ā ē ī ō ū (long)
ă ĕ ĭ ŏ ŭ (short)
ç (cedilla)
ñ (Spanish)

Symbols—& £ / $ % $^a/_c$ @ ℔ lb.

Reference Marks · * † ‡ § ‖ ¶.

These are sufficient to carry through books of a literary and general character, most newspaper work, and jobbing.

Special Signs and Spaces. There are, however, many other signs, symbols, or letters, used in scientific, mathematical, and other technical books, which are not included in the ordinary fount. In most well-equipped offices special cases are provided for fractions, index figures, and letters for chemical and algebraical formulæ, and other special signs.

To complete our fount we need spaces. These are classified in relation to the "em," which is the square of the depth of the type—Hair space, ¦ eight to em; thin, five to em; middling, four to em; thick, three to em; en quadrat, half of em; em; and two, three, and four-em quadrats:

The Evolution of Type. The original intention of printing was to imitate writing. Therefore the first forms of type closely resembled the characters of the books written at the time when printing was invented. Caxton's type was the "black-letter" used by the monks of Haarlem in copying out the Scriptures. But printing has developed a character of its own. The process of development is interesting, and from this table the stages of the evolution of type from ancient script to modern letters may be traced.

Caxton Black Letter.

Old English—Used in Caxton's time

Tudor—Used in the seventeenth century

Old Face—Almost obsolete.

Old Style—In general use to-day.

Roman—Called Modern, in general use to-day.

In book and newspaper work the types named "Old Style" and "Modern" are used mostly; but the trade is always progressing, and new forms of letter are constantly being devised. There is practically no limit to the variations; only a typefounder's catalogue can give an adequate idea of the immense varieties of fancy, display, and jobbing types.

The indispensable adjunct of every fount of book and news type is the *Italic* fount. This is a sloping form of letter. Originally designed for mere emphasis of a word or phrase, italic affords a handy way of distinguishing *foreign* words, words used *technically* in a sense different from their ordinary meaning, *sub-section headings,* and other items in the text.

Sizes of Founts. A fount of type has been defined as a complete set of letters, sufficient for use, of one size, weight, and form of face. Founts vary in size. There are two ways of measuring the size—the one according to the number of "a's" or "e's" in the fount, and the other by weight. Fancy types are usually measured by the first method; and book, newspaper, and type of which large quantities of the same size are used, by the second. The printer generally trusts the typefounder to supply the proper proportions of each letter; but in jobbing type especially, it is well that the workman should know how to measure a small fount. Here is a rough rule: Aa is four-fifths of Ee, and is equal to the leading vowels, consonants, periods, and commas, and double the minor letters. By keeping this rule in mind, the compositor will be saved from expecting to find three capital K's in 4A20a fount, and so on. Large founts are supplied by weight, and carefully proportioned in letter according to the number of times each is used in ordinary speech or writing.

There are many sizes of type. On the bill-hoardings great letters, four or five feet in length, announce to the passer-by the name of a great singer or a new patent medicine, and in some books and publications the eyes of readers are strained by type so small as to be almost undecipherable.

The Old Standard Size of Type. Between those extremes the sizes range in regular gradation. What may be described as the pivot or standard size is named "pica." The *Pica* was the Church Service Book, which was the staple product of the early printing trade. By simple transition, the type used became known as the pica type, and being the most common and familiar size, it became the standard. Until the Point System came into use, pica was the universal standard of type-measurement. Breadth of lines, depth of pages, length of columns, every general magnitude, was expressed in pica ems. As we shall see, this standard of measurement failed to satisfy the requirements of the trade. One very formidable discrepancy occurs in the type itself, some founders giving seventy-two ems to the foot, and others giving seventy-one ems for the same length.

The Old Styles of Types. The printing trade was not many years old before printers began to make different sizes of type. No standard regulated the original designs of letters; artistic effect and convenience were the sole motives of those ancient type-makers. Sizes of type were not known by their relation to the standard; and, indeed, they had no common measure, but were distinguished by arbitrary names. We give a table of the different sizes of type according to the old style, each name set in type from the class to which it belongs.

Brilliant	half of Nonpareil
Minikin	,, Minion
Gem	,, Brevier
Diamond	,, Bourgeois
Pearl	,, Long Primer
Ruby	,, Small Pica
Nonpareil	,, Pica
Emerald	
Minion	,, English
Brevier	
Bourgeois	,, Great Primer
Long Primer	,, Paragon

Small Pica Pica English

Great Primer **Paragon**

There are such types as two-line emerald, two-line brevier, and two-line small pica, but to tabulate them only helps confusion. The more sensible way is that adopted in stating the measure of large sizes—in terms of pica—two-line, three-line, four-line, and so on.

The above table is ragged enough, but when we remember that few typefounders have hitherto cast the type of the same name of the same size, the difficulty of finding a common measure for type seems almost insuperable. We have tested the long primer of five different typefounders, and they show a variation of from five and a half to three lines in the foot.

The "Point System." To-day, however, production must be rapid, cheap, regular, and in the highest sense mechanical. Standardisation of the tools, instruments, and materials of the trade, therefore, is absolutely essential. American printers were the first to perceive such a need, and they invented and adopted what is now known as the "Point System" of measuring and standardising type. Taking the millimetre as the unit-point, and approximating pica to twelve points, they proceeded to standardise all sizes of type.

The standard is the twelve-point or pica size. Pica measures one-sixth of an inch; therefore a point is one-twelfth of one-sixth of an inch. This point is mathematically determined, and remains a constant quantity. Having secured a firm basis, we proceed. All type is standardised to a given number of points. The change is not so revolutionary as it looks; the names and sizes are practically retained. The standard sizes between pica and nonpareil differ by one point. For example, pica is 12 points; small pica, 11; long primer, 10; bourgeois, 9; brevier, 8; minion, 7; nonpareil, 6. The sizes below differ by half a point: Ruby, $5\frac{1}{2}$, and pearl, 5 points: diamond, $4\frac{1}{2}$, and gem 4 points. The system works out exactly. Gem is 4 points, and half of brevier, which is 8 points: diamond is $4\frac{1}{2}$ points, and half of bourgeois, 9 points; pearl is 5 points, and half of long primer, 10 points.

How Type is Measured. Having a common measure, the relations of all the sizes of type are discoverable by simple arithmetic. One line of pica equals three of gem or two of nonpareil; two lines of pica equal three of brevier; three lines of pica equal four of bourgeois. With the point scale, and, of course, type cast to that scale, the printer can solve readily and accurately problems of type measurement otherwise complex and difficult.

The Point System not only standardises the depths of type, but it also regulates breadths. For instance, the young compositor tries to find out experimentally how many ems of long primer are contained in a line twenty ems of pica broad. He measures with a line of quadrats and finds that a hair space, or even a thin in addition to the 24 ems is needed. The Point System tells him at once that he is wrong; 20 ems of pica equal 24 ems of long primer, and they ought to come exact. The advantage of this in setting tables, and all matter containing different sizes of type in the same breadth, is very great.

Leads. All type is not set solid, with the lines close together. Spaces are put between the lines, and these spaces are technically named leads. Leads are strips of an inferior type-metal. They run in length from three ems upwards, and are standardised in thickness according to pica measurement. The thinnest leads are twelve-to-pica, and take that name. The leads most used are eight-to-pica, six-to-pica, and four-to-pica. Measured by the Point System, the leads are one-point (twelve-to-pica), two-point (six-to-pica), and three-point (four-to-pica).

Continued

EXTERNAL PLUMBING

Group 4
BUILDING
35

Continued from page 4872

The Tools and Materials for External Plumbing. Joints in Roof Covering. Lead Burning. Gutters and Flashings

By Professor R. ELSEY SMITH

THE work of the external plumber, with which that of the zinc worker and copper worker is usually included, consists principally in either laying the external coverings of roofs and other surfaces, or, where these surfaces are covered by slates or tiles, in protecting those parts of the roofs which are not completely protected by such covering; such positions, for instance, as the junctions between one roof and another, or at the junction of a roof with walls, chimneys, skylights, or dormers where, without such protection, wet would probably penetrate. The plumber also prepares and fixes lead pipes, but this latter work will be considered with internal plumbing. We shall first describe plumbers' work in relation to slate and tile roofs, and afterwards the complete covering of roofs and flats with sheets of metal.

Materials. The material used by the plumber is lead, cast or milled [see MATERIALS, page 358]. The former is apt to be uneven in thickness, is liable to flaws, and should, if employed, be used in weights heavier than those described for milled lead.

The great advantages of lead for roof work are (1) its absolute impermeability and extreme durability, if proper precautions are taken to prevent it being attacked by the acid contained in oak, and from galvanic action, and (2) its extreme malleability, which allows of its being bossed or dressed so as to lie close over irregular surfaces. On the other hand, its high coefficient of expansion, its weight, and its want of elasticity, make it necessary when executing lead work to take special precautions to allow considerable freedom for expansion and contraction due to changes of temperature.

Lead is described by its weight in pounds per superficial foot, and the following weights are usually employed for roof work:

4 lb. for soakers, and sometimes for cover flashings.

5 lb. for flashings and aprons.

6 lb. for covering ridges and hips, and sometimes for valleys, gutters and small flats.

7 lb. for valleys, gutters, and flats.

8 lb. to 10 lb. is occasionally used for flats exposed to traffic, and for soil pipes.

Plumbers' Tools for External Work. Scales for weighing lead are required, and should be capable of dealing with weights up to about a ton. A cord of about $\frac{1}{12}$ in. in diameter, rubbed with powdered chalk, is used for marking out lead; this is strained tightly over the line to be marked, and then *snapped* by being raised at the centre and suddenly released, thereby marking a white line on the lead. A knife, with a handle about 3 ft. long, is used for cutting up lead; a cord is passed through the blade, as it requires two men to use this knife [58]. A sharp pocket-knife, with a large pointed blade, is also used by plumbers [59].

The *plumber's hammer* [61] has a head for driving nails, and the nose is brought to a thin edge, which is used for running between edges that are to be soldered. The *gauge hook* [60] and *shave hook* [62] are used for taking thin shavings from surfaces which are to be soldered. For soldering work, a portable fire may be used. The *plumber's devil* [63], in general use for this purpose, is made in various sizes, and consists of a circular container of sheet-iron, perforated with holes and a grate below; it stands on three legs and has at the top an arched bar on which to hang a melting pot. There are also various forms of plumbers' stoves, which may be used in place of such a fire. The *solder pot* [64] is of cast iron, mounted on three short legs, and with a loop handle for carrying. *Ladles* [65] of various sizes for melting and carrying liquid lead or solder are required, and *plumbers' irons* [66] of various sizes are used.

Copper bits or *bolts* or *soldering irons* are pieces of copper specially shaped, fixed to an iron holder, which in turn has a wooden handle [67].

Dummies [68] are lumps of lead formed on the end of a straight or curved piece of iron and shaped, and are used for taking dents out of pipes.

The *plumber's rasp* [69] has one flat and one rounded side, and should be of medium cut. If coarse, it drags the lead; if fine, it clogs.

A *straightedge* is required for testing the trueness of edges shot for soldering, and is a piece of well-seasoned wood with the edge shot perfectly true.

Mandrels [75] are used for making pipes on, and are cylinders of soft wood of various lengths, slightly smaller in diameter than the pipe to be made, slightly tapered to allow of withdrawal; for trumpet-mouth wastes they are made three times as large at the top as at the bottom.

Turnpins [70] are conical pieces of wood, and should be of boxwood, and quite truly turned; they are used for enlarging the ends of pipes for forming junctions.

Bobbins [76] are turned balls of boxwood, which are placed in pipes that are to be bent.

The *bolt* or *pin* [74] is a curved piece of wood used in forming openings for branch joints, and sometimes for bending.

A *mallet*, of boxwood, is used for bossing lead.

Dressers [71] are made in various forms, and are used for dressing down lead; they have a handle by which they are grasped. The *step setter* [72] is similar, but in the underside has a groove, which fits over the lead in setting or bending the top of the steps in step flashings.

In addition to the above implements there are certain materials required. With a tallow candle, lead surfaces that have been shaved are "touched," to keep them from tarnishing.

Resin in block is used as a flux in soldering, and is carefully and evenly powdered; this is placed in a *resin box* [73], which has a conical head, terminating with a single aperture, of not more than $\frac{1}{8}$ in. diameter.

Soil, or *smudge*, is composed of lampblack and chalk finely and evenly ground, and mixed with water or beer, as stiff as mortar, to which some melted glue is added and thoroughly incorporated till it is of the consistency of cream. It is kept in a copper pot, and is used for painting on parts of lead to which solder is not required to adhere.

Chalk is used for rubbing on lead to remove all traces of grease before soldering.

Solder is a mixture of lead and tin, with, in some cases, bismuth, mercury, or cadmium mixed in varying proportions for different classes of work, and used to join two surfaces of lead or other metal. The most usual solders are the following:

Name	Lead	Tin	Melting Point
Coarse	3	1	480° F.
Plumbers' ..	2	1	440° F.
Fine	1	1	370° F.

For making *burnt lead joints* a special apparatus for generating hydrogen gas and mixing it with a proper proportion of atmospheric air is required: this is fitted with a flexible tube and a blowpipe.

Nails for fixing leadwork are usually of copper, with large heads. For ordinary or open nailing they are used at intervals of 3 in. to 4 in.; for close nailing they are spaced not more than 1 in. apart.

Joints in lead flats and gutters may occur across the fall or parallel to it.

Joints Across the Fall. The simplest is a *lapped* joint [**77**]; this may be used when the slope exceeds 20°, and in making it the top edge of the sheet, after it is laid, is secured with copper nails, and the lower edge of the next sheet, when laid, covers it for about 6 in.

A *welted* joint may also be used where there is a fairly good fall: in this the lower sheet is copper-nailed about 4 in. below its upper edge, the end turned up, the lower end of the upper sheet turned over it, and the whole then turned and dressed down to cover the nails; or a strip of lead or copper may be nailed to the roof and folded into the welted joint instead of nailing the lower sheet [**78**].

In ordinary horizontal gutters and flats, where the fall is usually about 1½ in. in 10 ft., or 4 deg., none of the joints described above is satisfactory, and a *drip* must be used to make the joint. This is an abrupt change in the level of the roof, and such a drip is usually 2 in. in height [**79**].

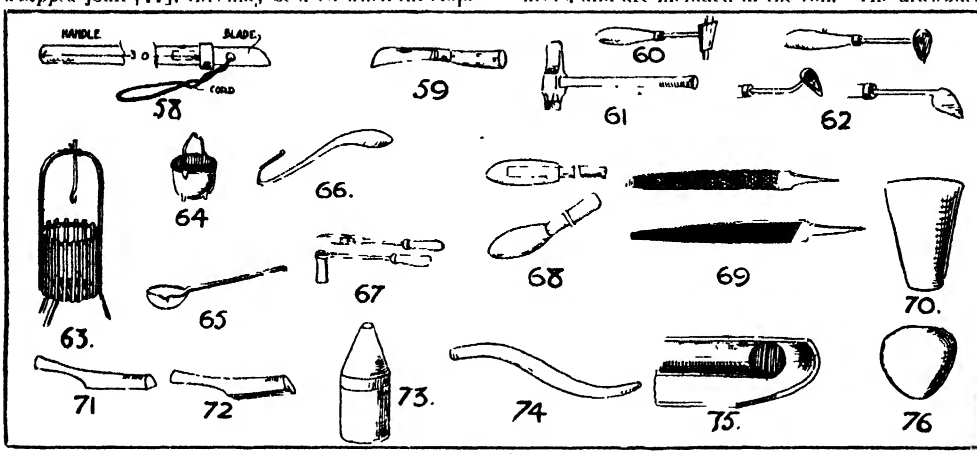
The face of the drip may be vertical or an angle fillet, or a quarter round fillet may be introduced. The edge of the boarding at the top is rebated to a depth equal to the thickness of the sheets of lead in use, and for a width of 1 in. to 1½ in. In making the lead joint the upper end of the lower sheet is dressed up over the drip and down into the rebate, and nailed with copper nails; the lower end of the upper sheet is dressed down over the drip, and may be cut so as not quite to reach the bottom, or it may be dressed down for 2 in. or 3 in. on the flat surface below the drip.

Before the upper sheet is laid, *tingles* [**79**], which are strips of stout lead (7lb. or 8lb.), and about 1½ in broad may be nailed to the upper level of the flat and dressed down over the drip, being made long enough to be turned up over the lower edge of the upper sheet when it is laid, a device which grips the edge of the sheet and helps to secure it in position.

Joints Parallel to the Fall. Where several sheets of lead have to be laid side by side a special joint is required, to allow of expansion and contraction, as a soldered joint cannot be made.

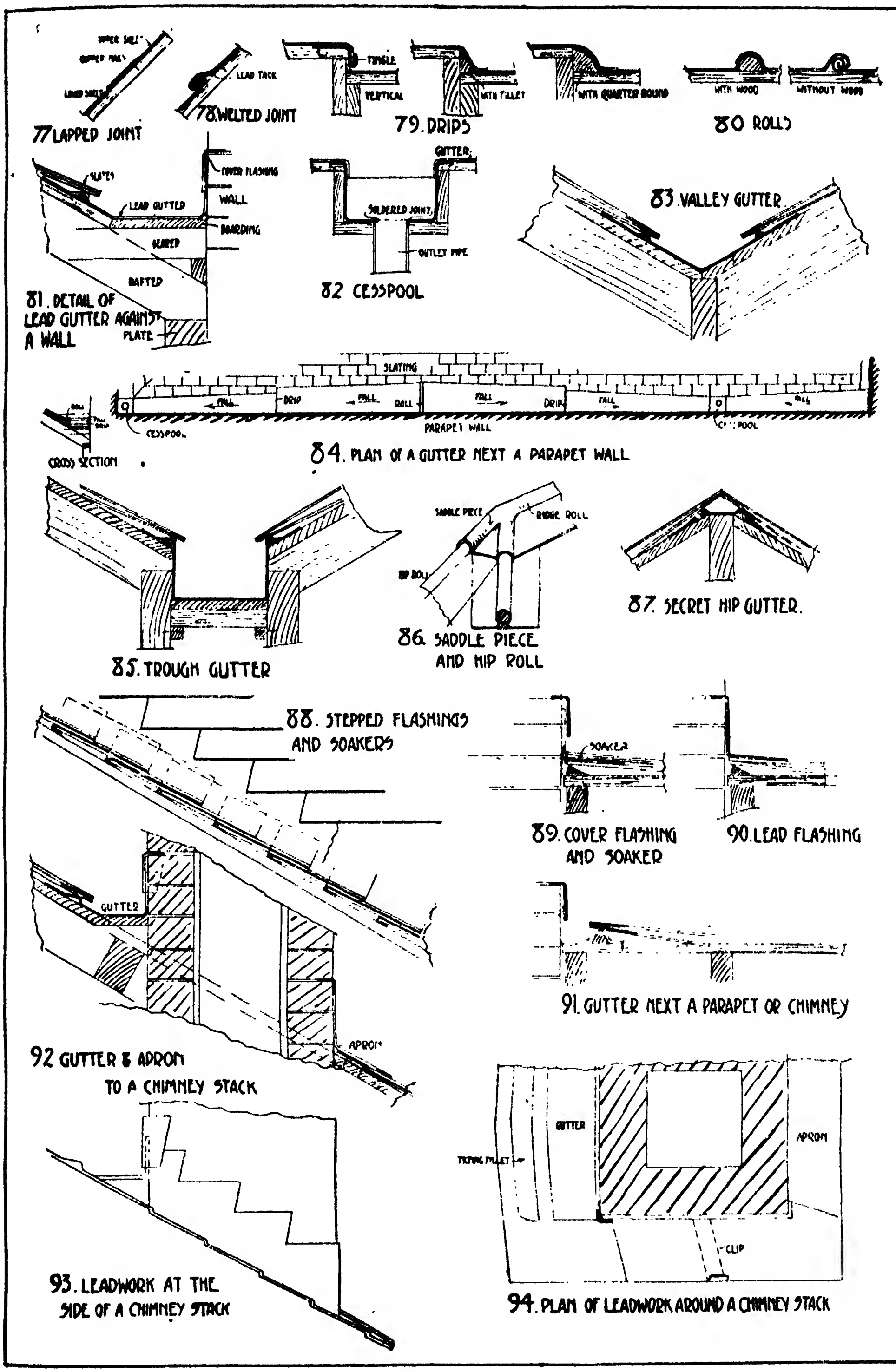
The joint universally used is a *roll* [**80**]; this may be made in two ways. The first is to turn up the ends of both sheets side by side, one being slightly longer than the other and turned over it, and then to fold the two together into a roll. Lead tingles are required at intervals to hold down the sheets, and are included in the roll. The drawback to this joint is that the roll, being hollow, is liable to damage. The more usual form of roll requires a solid roll of wood to be nailed parallel to the side of the sheets, and this is usually of 2-in. diameter, and in section forms about three-fourths of a circle. The edge of one lead sheet is dressed into the hollow between the roll and the flat—care being taken not to crack it where it is bent—and bossed up over it and carried round about two-thirds of the roll and copper-nailed. The adjoining sheet is then dressed into the hollow on the other side of the roll, and over it, covering the edge of the first sheet. It may either be taken about two-thirds round the roll and stopped, in which case lead tingles are required to clip the edge, or it may be carried right round the roll, dressed into the hollow between it and the flat, and, for a short distance, on the flat. The latter method gives a better grip of the roll; but if water lies near the joint, there is some danger of it being drawn up between the two thicknesses of lead by capillary attraction.

The distances between the rolls vary somewhat with circumstances, but when possible they are usually set out to allow of two sheets of lead being cut from the width of an ordinary market sheet, which



PLUMBERS' TOOLS

58. Plumber's knife **59.** Plumber's pocket-knife **60.** Gauge hook **61.** Plumber's hammer **62.** Shave hooks **63.** Plumber's devil **64.** Solder pot **65.** Ladle **66.** Plumber's iron **67.** Soldering irons **68.** Dummies **69.** Rasps **70.** Turnpins **71.** Dressers **72.** Step setter **73.** Resin box **74.** Plumber's bolt or pin **75.** Mandrels **76.** Bobbin



EXTERNAL PLUMBING WORK

may measure 7 ft. 9 in. across; allowing for the lap, this requires the rolls to be spaced at intervals not exceeding 2 ft. 10½ in. from centre to centre.

The lower end of a roll has the lead bossed over it so as to encase the end completely, and if this end comes above a drip the leadwork is dressed down over the roll that occurs below the drip. If the roll forms the watershed of a gutter falling both ways, the lead work is dressed up against the parapet wall or under the slates as the case may be.

Soldered Joints. These cannot be much used in lead roofs owing to the undesirability of fixing the edges of adjoining sheets, but may be used in forming cesspools, in repairing work, and in making soil pipes. Solder is supplied in the form of long sticks which vary in form. A joint that is to be soldered must have the edges, if they are butted, perfectly true. They are rubbed with a little chalk to free them from grease, and then the surfaces are painted with smudge; after this is dry, the portions to which solder is intended to adhere are shaved with a gauge hook or shave hook. The work is held together by melting in bits of solder at intervals while the edges are held firmly together; the joint is then sprinkled with resin, and the solder laid in the seam with the help of a copper bit. This is at first done roughly, and after again sprinkling a little resin the heated bit is passed smoothly and evenly along the whole length, so that the solder floats truly and evenly after it, making a firm, even band.

Lead Burning. Lead burning is not so commonly used as soldering, but makes an excellent joint; it may be used for welted or lapped joints, both horizontal and vertical. The surfaces must be shaved. Lead burning is specially serviceable in connection with chemical works, but makes excellent builders' work also. Solder is not employed, but a stick of lead is used and melted on to the joint by the blowpipe, already described, in a series of small drops or beads, each one covering partly the one below it. The process consists really in melting the edges to be united with the addition of some extra metal of the same kind, if necessary, so that they flow together and unite perfectly. The advantages of such joints are that, as the metal in the joint is the same as in the parts united, the whole is homogeneous and will resist uniformly chemical action and the effects of expansion.

Leadwork to Slate Roofs. No leadwork should be fixed in lengths longer than 10 ft., and where it is possible to arrange for 7 ft. lengths, it is better; in most cases not more than two edges of a rectangular piece of lead should be fixed.

Roofs, valleys, and gutters that are to be covered in lead must be properly prepared [see CARPENTRY], so that the surfaces are not flat but have a sufficient fall with all drips and rebates and rolls required, and it is important that the boarding should be laid in the direction of the fall of the roof, valley, or gutter, so that, in the event of the boards curling somewhat, any small ridges that are formed shall be parallel to, and not across, the flow of the water.

Those parts of the leadwork of a slated or tiled roof which are to be covered by the slates or tiles must necessarily be laid before the slating or tiling is executed; and such work includes all forms of gutters. Flashings, drips, and ridges and similar work are completed after the slating or tiling is finished.

Parapet Gutters. Where the roof terminates behind a parapet, a gutter must be formed to carry off the water from it. The outlet must be at the lowest part of the gutter, which should have a width of at least 9 in. at this point, and, as the level rises, the width of the gutter will increase to a greater or less extent—depending upon the pitch of the roof—till the first drip occurs; at this point a sudden increase in width takes place, thence again a gradual increase till another drip, and so on. It is therefore economical, wherever possible, to arrange the outlet near the centre of the gutter, so that it may fall in two directions. In the case of a long gutter more than one outlet is required, with falls from two directions to each of them [84].

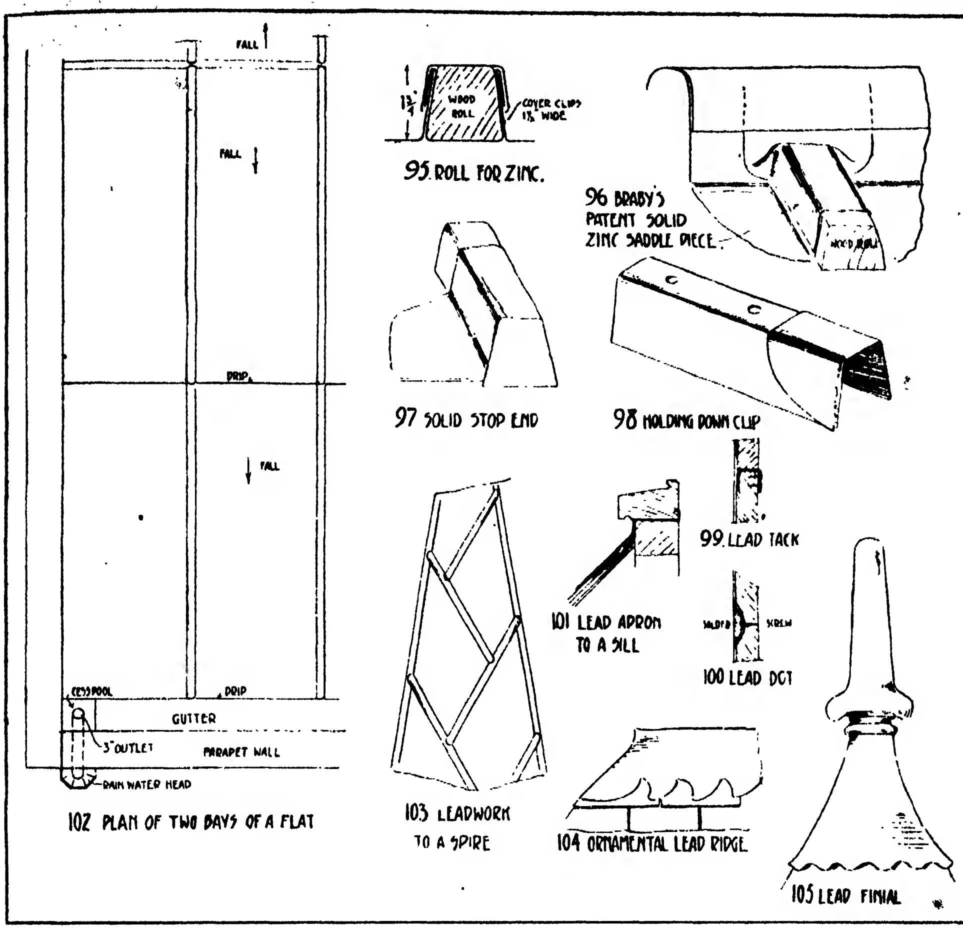
The Cesspool. The outlet itself usually takes the form of a cesspool, which is a square wooden box, the minimum size being 9 in. square and 6 in. deep. The bottom is perforated for a lead pipe to form the outlet. This box is prepared by the carpenter, and when possible should be lined by a single piece of 7 or 8 lb. lead bossed out to the required shape; or where this is impossible the seams must be soldered or burnt. The outlet pipe is of 7 or 8 lb. lead, or a drawn lead pipe may be used 3 in. in diameter or larger, and it often takes the form of a swan-neck. The lower end delivers into a rain-water head; the upper end is bossed out and soldered to the lining of the cesspool. The upper part of the lead cesspool lining is dressed down into a rebate prepared for it in the gutter board, and close copper-nailed.

Lining the Gutter. The leadwork of the gutter is cut from a broad sheet. The bottom or sole of the lowest length will be 9 in. wide at its narrowest point; it has one edge turned up 5 or 6 in. against the parapet; the other edge is turned up the slope for about 5 in., then over a tilting fillet and for a distance of 3 in. beyond this, where it is copper-nailed. If the cesspool occurs at the end of the gutter and the parapet is returned, the end must be bossed up so as to stand 5 in. up against the return wall. The sole is perforated for the cesspool; the edges are dressed down over the sides of the cesspool, and a soldered joint may be made between the gutter and cesspool, otherwise, should the outlet become stopped, water might rise above the level of the top of the cesspool and find its way under the leadwork of the gutter.

Wherever possible a free outlet should be provided through the parapet wall at or near the lowest level of the gutter so as to provide against any temporary blocking; and in some cases, in place of any cesspool, an outlet may be formed in the wall, the lead being taken through and formed into a shoot to discharge direct into the rain-water head. Every cesspool should be provided with a copper or galvanised iron wire dome, fitting over the outlet to keep back leaves and other obstructions.

The upper edge of the first piece of lead in the gutter is carried up over the first drip as described. The next length of the gutter has the lower end bossed to fit over the drip, and the portion that lies in the slope of the roof is not cut perpendicular to the line of the gutter, but extends forwards. This insures that any water dropping off the slates near the joint shall easily run down the lead and not tend to be drawn in between the two thicknesses. This length will start with a width as wide as that of the finish of the previous strip and will increase in a corresponding manner.

The upper end will be finished in the same way if there is another drip, but when the highest part of a gutter is reached, if the parapet wall is returned, the upper edge of the lead is bossed up to stand against the wall; but if the gutter falls again from this point in the opposite direction a roll is used to separate the two slopes and the ends of the lead are dressed over it.



EXTERNAL PLUMBING WORK

Cover Flashings. When the leadwork of the gutter is in position the edge next the parapet stands up close to the wall. But as the other edge has been nailed under the slates this cannot be fixed, and to prevent water getting behind it a *cover flashing* is employed [89]. This consists of a strip of lead about 6 in. wide, of which a width of 1 in. is bent to form a right angle, and is inserted into the joint between two courses of bricks which has been raked out for the purpose, or, if the parapet be of stone, into a chase that has been cut for it termed a *raglet*. The lead is secured with lead wedges driven into the brick joint, which is afterwards pointed in cement, or into the raglet, which is afterwards run or filled with molten lead, this being termed *burning-in*. This completely covers the top edge of the lead gutter, and any water running down the face of the parapet is discharged on to the sole of the gutter.

A gutter between two parallel sloping roofs is formed in a similar manner, except that a tilting fillet must be provided for the lowest course of slates or tiles on each slope; and as the width of such a gutter is increased at both edges it may become necessary, if the gutter is a long one and if the sole becomes very wide, to divide the width by a roll.

Trough Gutters. It is, however, often possible in such positions, if the rafters of the two roofs are carried on pole plates, to use a *parallel-sided* or *trough* gutter [85]. This differs from the one already described in having the upper edge of the gutter at a uniform level below the eaves, but the bottom is formed with the necessary slopes and drips, entirely contained in the depth of the gutter between its vertical sides.

A valley gutter formed where two sloping roofs intersect [83] has always a fairly rapid fall, and can be constructed without drips. Such a valley is prepared for by nailing two tilting fillets one on each roof, parallel to the angle between them and at least 6 in. from the angle.

The lead is cut into parallel-sided strips long enough to allow of its being dressed down into the valley over each tilting fillet and to extend beyond it for about 3 in. to 4 in. on the roof, where the edges are copper-nailed. Lapped joints are used, and at the top of the roof the valley pieces are brought up on each side of the ridge and a *saddle piece* used, covering the ridge and dressed down to cover the upper part of both valleys. Lead valley gutters are made at least 8 in. wide, so as to allow workmen to walk on them when roof repairs have to be executed.

Leadwork to Hips. Secret hip gutters are used when the slates are finished as close cut without any external cover. Such a gutter is

prepared for like a valley, but the tilting fillets are placed only 2 or 3 in. apart so as to allow of a narrow gutter between them [87]. The lead is dressed down into this over the fillets and copper-nailed to the roof boarding. The tilting fillets in both valleys and hips not only serve as an edge or margin to the valley, but raise the outer edge of the slates, throwing back the water on to the slate slope rather than into the lead gutters.

Lead soakers may also be used to protect the hips. These must be specially shaped; the length equals the length of the slate less the gauge, with an additional inch for turning over the top. The centre of the soaker lies over the hip, and the two wings lie on the back of the slate on each side, leaving the margin exposed. Such a soaker is used at every course, and effectively prevents water from entering.

Hips may also be protected by strips of lead wide enough to be dressed over a roll nailed above the hip rafter [86] and down over the slates on each side for a breadth of 6 in. to 8 in. Lead tingles are fixed to hold down the edges [86].

Ridges may be protected in a similar way by the use of a roll covered with lead and lead wings; the lengths used should not exceed 7 ft., and the joints are lapped. Where hips run up into a ridge, the junction is formed with a special capping piece bossed over the ridge and down over both hips.

Junctions Between Roofs and Walls. Where a roof abuts against a parapet, wall, or chimney, the best method of making the joint is to use soakers, one to each slate, which in this case are rectangular. One edge is turned up against the wall for 3 in. to 4 in., the rest of the soaker lies on the slate, and may be turned over its head. The upturned ends are protected by a *cover flashing* let into a raglet in stone walls, but in the case of brick walls, the upper edge is *stepped*—that is, a series of triangular pieces are cut out to allow the lead to be turned into every horizontal brick joint [88 and 89]. The upper edge of the lead is prepared with the help of a *step setter*.

Another method is to use a *stepped flashing* secured to the brick joints and dressed down on the top of the slates for a width of 6 in. to 8 in., and secured by tingles without any soakers [90]; but if the edges are raised by the action of wind, wet may blow under this. Another method is to form a narrow gutter by stopping the slating 3 in. or 4 in. from the wall [91]. The side of the gutter may be formed by a tilting fillet or roll under the edge of the slates. This is best lined with lead nailed under the slates and turned up against the wall with a stepped cover flashing, but is sometimes formed with a single width of lead, the upper end stepped and secured to the wall.

Leadwork to a Chimney. Where a chimney stack occurs in a roof, the joint between it and the slates must be protected all round. This is done by an *apron* on the lower side of the slope [92]. This apron is a strip of lead 12 in. wider than the width of the stack and deep enough to stand up against the brickwork for 5 in. or 6 in.—the top being turned into a brick joint—and to be dressed down over the slates for at least 6 in. The sides are formed with stepped flashings, or soakers and cover flashings [93], long enough to turn round the lower face of the chimney for about 2 in., the lower edge, where it is dressed over the apron, being cut away to a slope, and the edges of the flashing are secured with tingles [94]. At the back of the chimney a narrow gutter is formed, the leadwork at the ends being dressed down over the slates, and turned round the angle of the chimney and covered with a flashing, which is also returned on each face [92-93].

A skylight or trap-door projecting above a roof is protected in the same manner, but the lead is usually cut wide enough to cover the vertical sides of the skylight, and is very usually turned over the top of the kerb and close copper-nailed to it under the frame of the light. Where dormers project from slated and tiled roofs, if the vertical sides are slated or tiled, the junction between the roofs is made by means of soakers. Where a skylight kerb or window sill stands above a slated or tiled roof, a lead apron is often employed to secure a watertight joint below the wood sill, and the lower edges of the apron may be ornamentally cut [101 and 104].

The apex of a circular or pyramidal roof is also often protected by a lead capping, which may be dressed over the timber finial and down upon the roof covering [105].

Lead-covered Roofs. For the most part roofs wholly covered with lead are as nearly flat as possible. They are prepared by the carpenter, and must be laid with a regular fall, as described for gutters, with drips at intervals of from 7 ft. to 10 ft., and with rolls at every joint in the lead, which is parallel to the fall. The highest part of the flat has the lead turned up against the wall or parapet if one exists, and is covered by a cover flashing, or, if the flat falls in two directions, over a roll [102]. The outermost sheets have also the outer edge turned up against the wall with a cover flashing, and if any chimney or skylight projects through the roof, the lead must be turned up all round. The lower edge of a flat generally delivers into a trough gutter lined with lead, and must be turned and dressed down over the edge. In some cases it may be necessary to make use of an iron gutter to carry off the water, and the lead must then be fixed so as not to be at any point in contact with the iron; it should be dressed over a fillet, so as to drip well into the gutter without touching the iron. Where the pitch of the roof exceeds 20 deg., welted joints may be used in place of drips.

If the edge of a flat is formed by a moulding, and in other situations where mouldings occur, the leadwork may be dressed over them and into the hollows of the mouldings with the help of bossing mallets and dressers, care being taken not to crack the lead, and to keep the thickness of the sheet as nearly uniform as possible.

Lead in Steep Roofs and Vertical Faces. Where surfaces are vertical or inclined as a steep angle, and have to be covered with lead, at in the case of spire and turret roofs, if the rolls are placed vertically, the outer edges of the sheets which are not fixed gradually *creep*—that is, they move down the roof owing to the weight of the sheets and the want of elasticity of the material, which does not regain its former position after expansion. In such roofs, therefore, the rolls are arranged diagonally on the roof, so as to reduce the strain on the lead sheets, and give a more direct support [103]. Where vertical surfaces, such as the sides of dormers, have to be covered with lead, the sheets are generally turned over the upper edge when possible, and close copper-nailed; but additional supports are required to prevent the heavy sheets from tearing away. These may be afforded by soldered dots, and when such a dot is to be formed, the boarding is prepared by forming a cup-shaped sinking, and the lead is dressed into this and secured with a brass screw [100]. A ring of smudge is painted round the hollow, so as to extend about 2 in. beyond the

dot, and the surface of the lead in the hollow is shaved, sprinkled with resin, and is filled in with melted solder, poured in from a ladle; this forms a solid dot, the face of which is flush with the outer face of the lead, thus forming a support for the leadwork, and covering the head of the screw. Another method sometimes adopted is to solder to the inner face of the lead sheet strips or tacks of stout lead, which are passed through slits formed in the boarding and nailed from inside [99]. A slight sinking must be formed in the outer face of the boarding to receive the end of the tack where it is soldered against the sheet.

Lead for Horizontal Surfaces. Lead may be used for protecting horizontal surfaces exposed to the weather, such as the upper surfaces of wood sills, and of wood plates in half timber work. The upper edge is usually close copper-nailed and the leadwork dressed down over the surface to be protected. The upper surface of brick strings may be protected by a lead flashing, instead of by a cement weather fillet; the top is turned into a brick joint, wedged and pointed, the lower part dressed over the brickwork, and is sometimes arranged to form a drip. The upper surfaces of stone cornices and projecting mouldings may be protected in the same way, the lead being fixed in a raglet. Projecting stone porches are similarly treated; where the surfaces to be covered are extensive and the inclination considerable, welted joints may be formed and the lead secured to the stonework by means of soldered dots.

Lead may also be cast into ornamental forms for certain purposes such as rainwater heads and the ornamental tacks often employed for securing lead pipes to wall surfaces; in such cases moulds must be prepared, into which the lead is poured in a molten condition.

Zinc Work. For ordinary purposes zinc [see page 359] is used as a substitute for lead in work of an inferior quality, and in much the same way as lead. It cannot be dressed and bossed as lead is, but good zinc can be bent readily without cracking. Its advantages are its lightness and cheapness compared with lead; its drawbacks, the comparatively short time during which it remains in good order, and its liability to attack by air containing acid, by soot, and by the urine of cats. Its expansion and contraction exceed that of lead, and it must not be laid in contact with iron, copper, or lead, or with wood containing acids. The zinc itself should be free from iron or it will not resist the attacks of the air. There is a special gauge for zinc, and the following are the weights generally in use:

No. of gauge.	Weight per foot super. in ozs.	No. of gauge.	Weight per foot super. in ozs.
10	11½	14	18¾
11	13¾	15	21¼
12	15	16	24¼
13	17	18	30¾

The gauges 10 to 12 should be used only for very cheap or temporary work; 13 is the lightest that should be used for reasonably good work in flats, etc., and this should be employed only where economy is an important point; 14 to 16 are the proper weights for flashings, flats, gutters, etc., and nothing less should be used for the latter. Soakers, flashings, and cover flashings, both stepped and plain, are formed similarly to those of lead, but the lower edge of cover flashings, drips, etc., have a small bead formed on the edge, and should be turned into the joint or raglet for 1½ in. Zinc is usually rolled in sheets, 7 ft. or 8 ft. long, but can be specially rolled up to 10 ft. long. The modern system of fixing zinc work in roofs without the use of solder or any perforations in the external sheets was introduced by Messrs. Braby & Co., who are the agents for the Vieille Montagne zinc, which is very free from iron. The fall in a flat to be covered by zinc should be 2 in. in 8 ft., and the drips are formed at intervals of 7 ft. 6 in. as a rule, and should be at least 2½ in. deep. Wood rolls are usually fixed 2 ft. 11 in. from centre to centre, and are not round, but 1¾ in. high and diminished from 1¾ in. at the base to 1¼ in. at top [95]. The sheets of zinc are turned up against the roll at each side and secured by zinc clips, which are strips 1½ in. wide fixed under the wood roll and turned up over the edges of the sheets, which are placed not more than 3 ft. apart. The lower edge of the sheet is turned down over the drip, the upper edge is turned up, a fold being formed at the angles.

The wood roll is covered by a zinc capping. The upper end of the capping is secured by folding it down behind the end of the roll, and then up so that it is covered by the lower end of the next roll above it, or, if against a ridge roll, is turned up under the capping of the ridge [96]. The lower end is folded over on itself and turned under the end of the roll, so that the whole capping is formed without solder, and is self fixing. Should a joint be necessary in the length of a capping, as, for example, in a ridge, a special piece is used for making the joint, one end of which is folded back on itself [98]; this special capping fits over the ordinary capping first laid, and is screwed through the top to the wood roll, and the end of the next piece of capping is then inserted under the fold, which securely holds it, and the new length entirely covers the heads of the screws.

When the fall of a roof exceeds 1 ft. in 8 ft., welted joints as described for lead may be used in place of drips. Moulded eaves gutters, if formed in zinc, require hollow zinc stays at intervals of 18 in., and may be fixed by means of long screws driven through these stays with or without clips fixed to the facia. Roofs may be covered with copper sheeting and capping on exactly the same principle.

Copper for Roofing. Sheet copper is used for covering roofs in the same manner as zinc. For such work it is specially rolled in lengths of 5 ft., 6 ft., 7 ft., and 8 ft. long by 3 ft. wide, and the drips and rolls must be set out to suit the sheets selected.

The gauge used for copper is the Birmingham wire gauge, not the special zinc gauge which is used for zinc.

The weights of copper sheets are as follows:

B.W.G.	No.	20	..	26	oz. per ft.
,,	,,	22	..	20	,,
,,	,,	24	..	16	,,
,,	,,	26	..	12	,,
,,	,,	28	..	8	,,

The gauges 22 to 26 are mostly used for flats, the details of which may correspond in all respects with zinc work. With a fairly good fall, welted joints may be made for both horizontal and vertical joints. For small turrets and domes, where the use of rolls would be awkward, a special capping may be used, the edges of the sheets being turned up to form a hollow; the capping is sprung in and kept in position by the sheets. Copper after some exposure becomes covered with a protective film known as verdigris, which is of a beautiful green colour.

EXTERNAL PLUMBING *concluded; followed by* JOINERY

HAT AND BONNET SHAPES

Cutting Out the Material and Fixing on Shape. How Velvet Should be Handled. Making and Sewing in Head Linings

By ANTOINETTE MEELBOOM

AN espatra or buckram shape will need a non-transparent covering such as velvet, silk, or cloth, which is often put on plainly. In handling velvet, the way the shade runs is an important matter. In ordinary velvet, the material should be arranged so that the darker effect is seen when looking from the front of the hat to the back. In panne or miroir velvets, the material is often arranged the reverse way. In cloth the nap should run smooth from the front to the back.

Cutting Out the Material. Take the paper pattern that has been used for cutting out the shape.

Place all the pieces on the velvet with the shade running in the same direction, and each centre-front to the cross of the material [80]. Pin each part with lillikins, sticking them into the table to prevent marking the velvet. Cut out each part with ½ in. turnings. For the under brim place the velvet upper brim pile to pile on the velvet in the same position. Do not cut out the head of under brim, as it is best to fit it first.

Notice carefully in the case of brims that are much larger on one side than the other, as those of the Gainsborough type, that the pattern is placed correctly for cutting. Allow more than the ½ in. turning for under side, as the brim turns up so much. This also applies to boat shapes.

Mark the centre-front in all the pieces. If the brim has a join at back, the velvet will also have a join, neatly slipstitched. When a piece is put in for making a very fluted brim, this will also be necessary in the velvet covering. Backstitch the joins, open out, and flatten the turnings.

Putting On the Covering. We have now to learn how to fit the velvet to the brim.

Upper Brim. Place the upper brim on hat, and snick round headline till it fits. Be careful neither to cut too deeply—in which case the shape will show—nor insufficiently, thus preventing it lying flat round the headline. Pin in place with lillikins, smoothing away any creases very gently, but only along the straight threads. If stretched or smoothed out on the diagonal threads, it will not set flat.

Large shapes must be tacked as well as pinned, to keep the velvet well to the curves. Fine silk should be used for this, and a long stitch taken outside, and a tiny one underneath. Backstitch evenly round headline

Draw the turning over the edge, but on no account pull it tightly, or the shape will contract. Pin all round. Catch stitch to the second wire on under brim [82], unless the under brim has been mulled all over, when the velvet is catch-stitched to the mull.

Cut away the turnings so that the velvet nearly meets the second wire to prevent any unnecessary fulness. Hold the brim with a small piece of velvet, pile downwards, in the left hand—the two piles facing each other prevents the brim from getting "plushed." Hold the brim very lightly, and prevent the edge getting plushed, or rubbed against the edge of a table or something similar.

Under Brim. For the under brim, place the velvet with the snick marking centre-front on the centre-front of shape. Fit and pin it in position as before. For large shapes tack once between headline and edge with fine silk. Cut off superfluous turnings to ½ in. With a fine needle turn in edge *exactly even* with the edge of brim. Pin with lillikins all round, about 1 in. apart. [81]

Slipstitch the two edges, with *strong* silk or cotton, taking alternately one stitch in the edge of the upper brim velvet and one in the turning of the under one. Sit in a good light, and be careful not to stretch the velvet of the under brim. Draw the silk fairly tightly. It is an operation requring great care, as this part of the hat shows more than any other.

Cut the headline with ½ in. turning, being careful not to snip beyond the actual headline, and stitch the turnings to headline of shape.

There is another method used in the best class of work, which gives a better edge, and is more satisfactory when an under brim of different colour or material is required.

Before covering the upper side of brim with velvet tack a piece of stiff French net, with the front on the cross, to the under brim. Tack it to the brim about half-way between headline and edge of shape. Cut it *exactly even* with edge, which must be wired with support wire, being careful not to contract the net. Mull the edge, and then cover the upper brim as explained.

Cover the under brim velvet, velvet-hemming the velvet to the net. The velvet must not be pulled tightly. Then slipstitch round edges of brim

The point to remember in this method is to keep the net lining exactly the same size as the upper brim. In the process of wiring it is likely, unless very carefully handled, that the net contracts or stretches.

Sideband and Tip. Line the tip with sarcenet. If not done at this stage, it will have to be gummed in. Cover tip with velvet, allowing ¼ in. turning; pin all round, smoothing it over shape across the straight threads only. Use long backstitch with strong cotton, and secure it below the edge of the crown. Cut away closely any turnings and sew in head lining.

Fit the sideband carefully, and cut away unnecessary turnings. With a needle turn in bottom and top quite even with edge of crown, placing the join where the trimming is likely to cover it, always keeping centre-front to centre-front of shape and dark shade running up [81]. Backstitch one end of sideband, turn in the other

end, and slipstitch it down. A sideband of silk will require an interlining of muslin, and thick velvets are also better for interlining in the centre.

The inner edge of standing-up brims like toreador, turban, and similar shapes needs careful handling. Keep it smoothly to the shape, and see that the join is neatly done. Secure the top edge to the under brim edge by a catch-stitch. The outer edge is slipstitched last of all, keeping the edges even with the shape. The band of crossway velvet is joined, slipped over the edge, and turned in top and bottom with a needle.

Tam-o'-shanter and beefeater crowns are covered in one piece cut in a circle. The foundation is of net or leno, pleated to the sideband [74]. For covering, cut a larger round or a half-round, the other half left larger for standing up at left side. In soft material it should be interlined with fine leno. Gather or pleat the crown to top edge of sideband.

Lining the under brim of a felt or straw hat plainly with velvet or silk is done in exactly the same way as the under brim of a velvet hat, the velvet being slipstitched just above the wire round edge. If a velvet hat is to be lined with crossway folds of silk, tulle or chiffon, a lining of silk, leno, or soft net must be tacked to under brim to sew the folds to.

A broad edge $2\frac{1}{2}$ in. to $3\frac{1}{2}$ in. wide of velvet on an under brim is made by fitting the velvet to the under brim, slipstitching the edges and cutting out the centre-piece, allowing for a turning to the inner edge. This edge will not have any join.

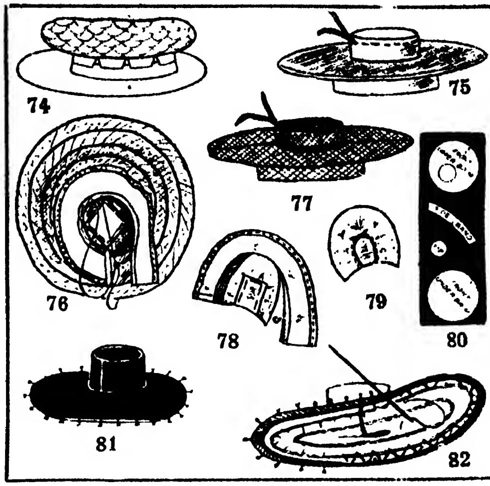
Bonnet shapes are cut out, shaded, and covered in the same way as hat shapes. Very few shapes are plainly covered. For covering shapes the velvet or cloth must be bought *on the straight*.

Head Linings. All hats, bonnets, and toques have their head linings sewn in *before* being trimmed. As weight must be avoided, sarcenet silk is used--it may be cut on the cross or straight. The former is the more economical, especially if a quantity is required; three head linings may be cut out of two crossway widths. Join the lengths first, hem, roll up, and use as required.

Measure the depth of crown, and add 2 in., of which $\frac{3}{4}$ in. is used for the hem, and $\frac{1}{2}$ in. for turning at the headline. When sewing in, allow 1 in. longer in length than the size of the head [76]. Make a hem $\frac{1}{4}$ in. wide of one cut edge, which should be run neatly [75]. It is called a hem though a running stitch is used, and must be kept quite straight and not stretched.

For the tip, cut a piece of sarcenet the size and shape of the tip. Sew in with a few very small stitches outside, large ones inside. For smooth felts, leghorns, velvet and cloth-covered hats, the sarcenet tip is gummed in, to prevent the stitches showing on the outside.

Sewing in the Head Lining. Use strong cotton (No. 36), start from the centre-back, turn in the cut edge $\frac{1}{2}$ in., and $\frac{1}{2}$ in. at the end. Take the stitch through the two thicknesses of sarcenet and through the sideband of hat. Sew in with the long back stitch, making the stitches not longer than $\frac{1}{2}$ in., and keeping them just below the line of head. Work from right to left. Turn in $\frac{1}{2}$ in. at end, and slipstitch the two



HOW SHAPES ARE COVERED
[Figures 74-82]

ends together. Smooth felt hats and toques have only half the thickness of the felt taken up when sewing in the head lining, unless the trimming will cover the small stitches; in that case, take them through, as it is stronger.

Run a narrow China ribbon from the centre-front in the hem, which will be drawn up *after* the hat is trimmed. It is left hanging to prevent the head lining being caught down in sewing on the trimmings.

Bonnets. In bonnets [78], the tip is cut to shape; in many cases, first sewn on tissue paper and sewn in the same way as for a hat, with this difference only, that across the back it is turned in once and slip-stitched on the velvet bind for neatness. Start the head lining at one ear, turning in 1 in., and work round to the opposite side. Insert China ribbon in hem, leaving also a turning; and, when the bonnet is trimmed, slipstitch the ends down the sides to meet at the back of the tip, securing ends of ribbon at the same time. Make a small slit in centre of hem, draw up ribbon, and tie in centre-front when bonnet is trimmed. Secure lining to the bonnet with a tie stitch in two places [79].

With smooth felt hats, toques, and bonnets with full or draped brims, the stitches are never taken right through, but only the top surface or inside of velvet is taken up. For very flat or peculiar shaped bonnets a piece of lining cut to shape is sewn in after the bonnet is trimmed.

Transparent head linings for lace, chiffon, tulle hats, or bonnets, are made of double chiffon, net and lisse. Cut lining twice the depth of sideband plus 2 in. for turnings [77]. Fold it in half and run $\frac{1}{4}$ in., from fold. Fold in half a sarcenet ribbon, the same colour as head lining, and $\frac{1}{2}$ in. wide. Place this ribbon in turning of head lining at the cut edges. Sew in as for sarcenet head lining, taking the stitches through the centre of the ribbon and turning of chiffon. The stitches will be hidden when the ribbon is folded over. Run China ribbon in hem from centre-front [82].

Continued

INTERSECTIONS OF CYLINDERS

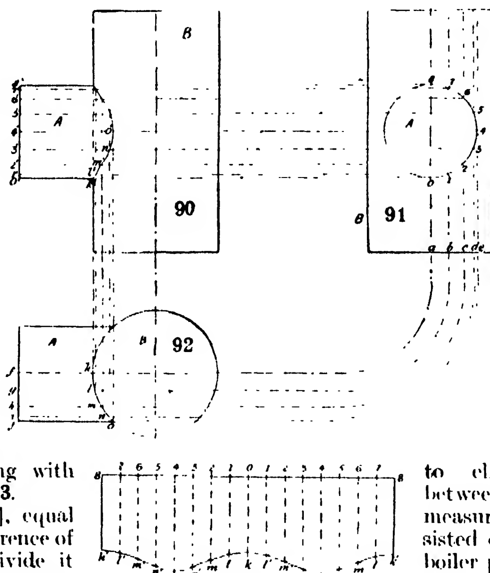
Cylinders Intersecting in various Axes. Union of Cylinder and Cone. Cylinder Intersecting a Polygon. Hemispherical Ends. Pipe Bends

By JOSEPH G. HORNER

Intersections of Cylinders. Two cylinders intersect in **90**. We have to find their lines of intersection. Three views are required: elevation, plan, and end view.

Divide the semi-circumference of the small cylinder, A [**91**], into any convenient number of equal parts 0, 1, 2, 3, 4, 5, 6, 7, 8. Through these draw vertical lines, 0*a*, 1*b*, 2*c*, 3*d*, 4*e*. 0*a* corresponds with the centre of the cylinder A, and 4*e* is tangent to its circumference.

Draw also horizontals, to **90**; 0 0′, 1 1′, 2 2′, 3 3′, etc. In **92** set off distances as follows: *fg* equal to *ab* in **91**, *gh* equal to *bc* in **91**, *hi* equal to *cd* in **91**. Through *g*, *h*, *i* draw horizontals cutting the curve of the larger cylinder B in *l*, *m*, *n*. The centre line already cuts the curve in *k*, and the periphery cuts it in *o*. From *k*, *l*, *m*, *n*, *o* now raise verticals to **90** intersecting the horizontals there; *k*′ already exists. The vertical line from *l* in **92** cuts the horizontal 1 1′ in *l*′ [**90**]; that from *m* cuts the horizontal 2 2′ in *m*′, and so on. Then *k*′, *l*′, *m*′, *n*′, *o*′ give the intersections of A with B round a quarter of the circumference.



90-93. INTERSECTIONS OF CYLINDERS

Development of Cylinder. To obtain the development of the cylinder A corresponding with **90** and **91**, proceed as in **93**.

Draw a line, 8 8 [**93**], equal in length to the circumference of the cylinder A, and divide it into as many equal parts as the circumference of A was divided in **91**, 0, 1, 2, 3, etc. Through these points draw lines perpendicular to 8 8. On these lines measure off in succession the lengths of the corresponding lines on A [**90**]. Thus, if the joint is to be made in the plane of the paper, then the length *o*′*k* in **90** will be transferred to 0*k*′ in **93**, and also to 8*k*′ 8*k*′. Then the lengths 1′*l*′ in **90** will be transferred to 1*l*′ 1*l*′ and 7*l*′, 7*l*′ in **93**; and the length 2′*m*′ in **90** to 2*m*′, 2*m*′, and 6*m*′, 6*m*′ in **93**, and so on. The points of intersection of the lengths taken on the verticals of A [**90**], four times repeated, will be the points through which the curved edge of A will be drawn to give its intersection with the cylinder B.

The points of intersection can also be obtained by the methods shown in previous diagrams, by projecting horizontal lines along from the points *k*′, *l*′, *m*′, *n*′, *o*′ in **93**.

Shape of Hole. The shape of the hole in the large cylinder B can be obtained as in **94** and **95**.

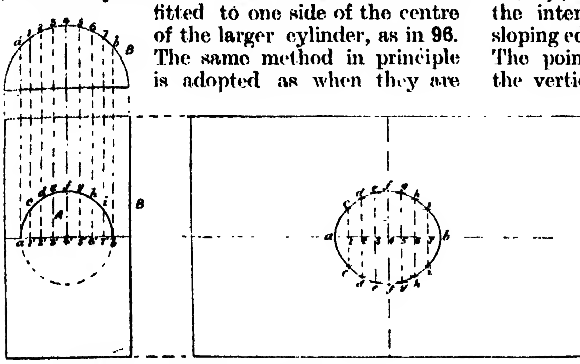
In **94**, B is shown below, in plan, looking down perpendicularly on the hole, and in half end elevation above. First draw the diameter *ab* of the cylinder A, and project the same to the view above, cutting its arc at *a*′*b*′. Divide the arc *a*′*b*′ into any number of equal parts 1, 2, 3, 4, 5, 6, 7, *b*′ and project perpendiculars thence to the lower diagram, cutting the diameter *ab* in 1′, 2′, 3′, etc., and the semicircle struck on *ab* in *c*, *d*, *e*, *f*, etc.

Next, in **95**, which represents the plate for the cylinder B, draw a diametral line *ab*. Take the arc divisions from **94**, *a*′, 1, 2, 3, 4, 5, 6, 7, *b*′ and set them off on the line *ab* [**95**] at *a*, 1, 2, 3, 4, 5, 6, 7, *b*. Clearly now, when the plate **95** is bent to the curvature of the cylinder B, the plane length *ab* in **95** must be equal to the arc length *a*′*b*′ in **94**, provided the divisions taken are sufficiently numerous to eliminate the difference between taking chord and arc measurements, as previously insisted on. Actually, in a large boiler plate, to which this problem frequently applies, the number of divisions taken might be three or four times as numerous as those given in these diagrams. The shape of the hole in the plate in **95** is now obtained from dimensions taken from the lower part of **94**. Take the length 4′*f* in **94**, and set it off on each side of 4 in **95**, 4*f* 4*f*. Take 3′*e*, in **94**, and set it off from 3 to *e e*, in **95**; and so on until all the dimensions in **94** have been transferred to **95**.

The lengths to right and left of the centre line, 4′*f*, in **94** are symmetrical—that is, 3′*e*, and 5′*g*, etc., are alike. Though in some constructions they would not be so, the same essential method must be pursued. In **95** the two curves lettered *acdefghib*, represent the elliptical hole in the plate, which when bent to the cylindrical

shape develops the circular hole of the same diameter as the cylinder A in 90-92.

Cylinders Out of Centre. Domes or other cylindrical branches are sometimes fitted to one side of the centre of the larger cylinder, as in 96. The same method in principle is adopted as when they are fitted over the centre, to which the example just given is applicable.



94, 95. HOLES FOR INTERSECTIONS OF CYLINDERS

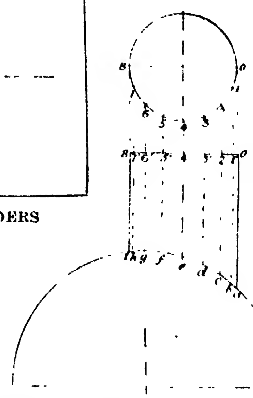
Divide the semi-circumference 08 of the plan above 96 into any number of equal parts, at 0, 1, 2, 3, 4, 5, 6, 7, 8, and project perpendicular lines therefrom to the base of the dome, cutting its upper plane in 0′, 1′, 2′, etc., and the base in *a*, *b*, *c*, *d*, etc.

In 97 draw a line AA equal in length to the circumference of the dome, and divide it into twice as many equal parts as the semi-circumference, 0′, 1′, 2′, 3′, etc., to right and left of the centre. From these divisions draw lines perpendicular to AA. The riveted seam is supposed to come down the shorter side of the dome, 8′*i* in 96. Therefore, starting from the centre of 97, make the length 0′*a* equal in length to 0′*a* in 96, repeated on each side of 0′*a*, 1′*b* in 97, equal to 1′*b* in 96, 2′*c* in 97, equal to 2′*c* in 96, and so on until 8′*i* is reached at each end. A curve drawn through these points, *a*, *b*, *c*, *d*, etc., will give the development of the curved edge. But the width for flanging will have to be added outside that edge, and also the lap for riveting down both the edges A*i*.

Cylinders on Angular Faces. Cylinders are sometimes fitted on sloping faces instead of on other cylinders. Figs. 98 and 99 illustrate the marking out of the envelope in such a case.

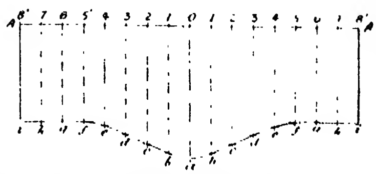
Fig. 98 is the elevation and plan of the cylinder. Half the latter is divided round conveniently, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, and vertical lines are drawn therefrom to the elevation above. These cut the horizontal end, *ab* of the latter in 1′, 2′, 3′, etc., and the sloping joint face, *cd*, in *e*, *f*, *g*, *h*, etc.

To obtain the envelope [99] draw a horizontal, *a′a′*, equal in length to the circumference of the cylinder, obtained either by calculation or by measurement from the divisions 1, 2, 3, etc. on the base of the cylinder [98]. Draw verticals from the points of division in 99, as shown, *a′c′*, 1*e′*, 2*f′*, 3*g′*, etc. Also draw horizontals from the intersections previously obtained on the sloping edge, *cd* thus: *ec′*, *ee′*, *ff′*, *gg′*, and so on. The points in which the horizontals intersect the verticals are points in the developed curve required, as, *c′*, *e′*, *f′*, *g′*, *h′*, to the centre *d′*, and so in backward order, *m′*, *l′*, etc. The complete outline of the developed plate is therefore *a′b′*, *a′c′*, *d′c′*, and one half only of the plate need be marked thus up to the centre, *b′d′*, and the other half therefrom. But it is usually just as well to complete the entire plate in the manner shown.

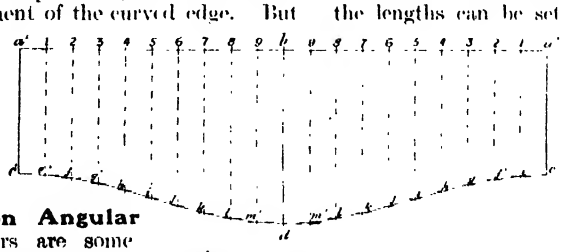


96. CYLINDERS OUT OF CENTRE

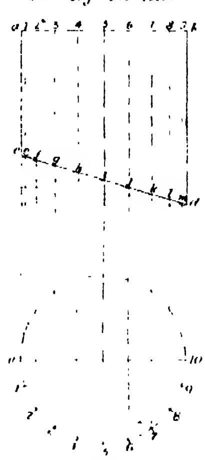
If it should not be convenient to draw the development in its relation to the cylinder, as often happens in big work for which a piece of plate is provided only just large enough to cut the development out of, then the horizontals cannot be drawn. Then, the verticals being drawn, the lengths can be set out directly on these—thus, from 98. Take the length *ac* [98] and mark that from *a′* to *c′* at the extreme ends of 99. Take 1′*e* [98] and mark that from 1 to *e′* twice in 99. Take 2′*f* and mark that from 2 to *f′* twice, and so on. This amounts to precisely the same as drawing the horizontals.



97. DEVELOPMENT OF CYLINDERS OUT OF CENTRE



99. DEVELOPMENT OF CYLINDER ON AN ANGULAR FACE



98. CYLINDER ON AN ANGULAR FACE

Jointing. In **99** the seam or lap joint is supposed to be added next to $a'c'$. If required at $b'd'$ then the pattern would, of course, be of the depth $b'd'$ at the extreme ends, and of the depth $a'c'$ at the middle. This would make no difference whatever in the method of obtaining the points of intersection. Or the joint might be down $5'i$ in **98**, which, again, would alter the shape of the plate. If the object be a dome, as would often be the case, an allowance for the flange must be made along the curved edge $c'd'c'$. This is not made until the outlines have been marked out as shown, after which the flange is simply an added width of, say, 2½ in. or 3 in., following the curve $c'd'c$ at a parallel distance.

Cylinders Fitting at Equal Angles. Two equal tubes [**100**] are united at an angle. We require the development of the sheets to have the seam either along the inner or the outer edges.

To obtain lines for development in **100**, divide a semicircle into a convenient number of equal parts, say twelve, and draw lines from these parallel with the sides of the cylinder and with each other, cutting the planes of the terminations of the cylinders at *a*, *b*, *a*, *b*, and *d*. Also draw a line, *ef*, anywhere transversely to the longitudinal lines of division.

To obtain the development with the seam, say along the inner edges *db*, *db*, draw a line, *ff* [**101**], equal in length to the circumference of the tubes, and divide it into twenty-four equal parts corresponding with those in **100**, and similarly numbered. Let the datum line, *ff*, represent the line *ef* in **100**, and from it on the points of equal division, 0, 1, 2, 3, etc., set off the lengths of the several lines of division in **100**. Thus, take the distance *ea* [**100**] and transfer it from 0 to a' in **101**; take the distance $g1'$ [**100**] and transfer it from 1 to $1'$ in **101**, the distance $h2'$ [**100**] to $2\ 2'$, $2\ 2'$ [**101**], and so on, until the points of intersection corresponding with the plane *ab* in **100** are all obtained. Then for the upper end measure off ee' [**100**] and transfer to $0e'$ in **101**; measure gg' in **100**, and transfer to $1g'$, $1g'$, in **101**, and so on, and draw the outlines, completing the sheet as shown.

Fig. **102** shows the sheet developed when the seam is on the outer edge; the same measurements are taken, as the references show.

An Ellipse Uniting Cylinder and Cone. Let us now examine the method adopted to connect a cylinder and a conic frustum with an elliptical fire-hole ring [**103**]. The fire-hole is seen in elevation at A, and in sectional plan at B, the section being taken along the middle plane *aa*. If the ring had to connect two parallel cylinders the views A and B would be sufficient, but as the inner fire-box is of conic section the view C must be added. D represents the outer cylinder, or shell, and E the fire-box. Very often the fire-box is dished outwards and connected with a parallel ring.

Two sets of intersecting lines at right angles are necessary. Divide the circumference of the ellipse A into any number of equal parts, 0, 1, 2, 3, 4, 5, etc, and project lines thence to B and C, cutting the lines D and E. In B draw two lines, FF, GG, tangentially to the arcs to afford the means of measurement to be transferred to the view C—that is, the lengths in B measured from $1'$, $2'$, $3'$, $4'$, $5'$, on the tangential line to the curve D on the same divisions will be transferred to the view C from the edge D, and similarly from the edge E of the other cylinder. The curve of intersection may be drawn as shown, though that is not necessary. But the points in the view C are now to be used for the development of the plate, thus:

In **104** draw a line, 00, equal in length to the circumference of the ellipse in A, and divide it similarly. In C draw a datum line *bb*. Now measure off to right and left of *bb* the lengths to the divisions in C. As corresponding reference figures are used in C and in **104** the construction is obvious.

A flange has to be added for riveting, or an edge for welding, but this does not affect the construction, but simply means an addition to the edge of **104**.

Cylinder Fitting to Hexagon. A large number of problems in sheet-metal working involve the attachment of objects of one form or size to those of another form or size—as squares to cylinders, cylinders to polygonal figures, small cylinders to large ones, and so on. There is not much difficulty in working out problems of these kinds after an example has been mastered.

Fig **105** illustrates a cylinder fitting on a hexagonal body. To describe the envelope of the cylinder proceed thus: Divide the semi-circumference in the plan view below into any convenient number of equal parts, 0, 1, 2, 3, 4, 5, 6, 7, 8, and project perpendiculars to the elevation above, cutting the hexagon at $0'$, $1'$, $2'$, etc., and the plane of the end of the cylinder AA at *a*, *b*, *c*, *d*, etc.

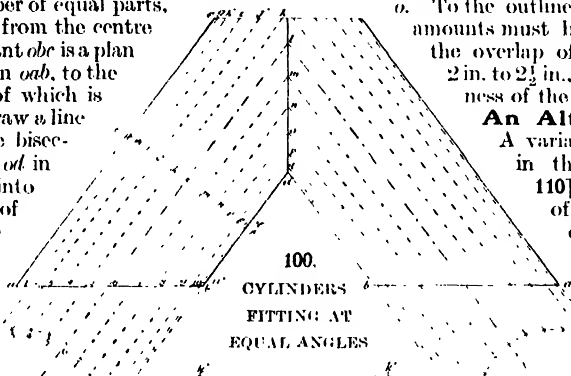
Next, in **106**, draw the line AA equal in length to the circumference of the cylinder, and divide it out into the same number of equal parts as the plan view in **105** (similarly figured), and draw lines therefrom perpendicular to AA. Take the lengths of the perpendiculars in the elevation of **105**, and transfer them to **106**, thus: The length $a0'$ [**105**] is transferred to $8\ 8'$ in **106**, the length $b1'$ in **105** to $7\ 7'$ in **106**, the length $c2'$ in **105** to $6\ 6'$ in **106**, and so on. Similarly, starting from the centre of **106**, $00'$ is equal in length to $a0'$ in **105**, $1\ 1'$ [**106**] is equal to $b1'$ in **105**, and so on, until the lengths $4\ 4'$ in the two deepest parts of the pattern in **106** are equal to $A4'$ in **105**.

Lines are now drawn through the points of intersection of the length with the verticals. There are, however, four locations not determined by these points—namely, *e*, *e*, *e*, *e* [**106**]. These correspond with the joints *e*, *e*, *e*, *e* in **105**, where the cylinder coincides with the angular edges of the hexagon. They are therefore obtained by measuring the arc $0e$ or $8e$, in **105**, and setting it along from $8'$ to *e* from both ends of **106**, and from $0'$ to *ee* in the central portion. If this be done correctly, then the distances $7'e$ and $1'e$ in **106** should be found equal to the distances $1e$ and $7e$

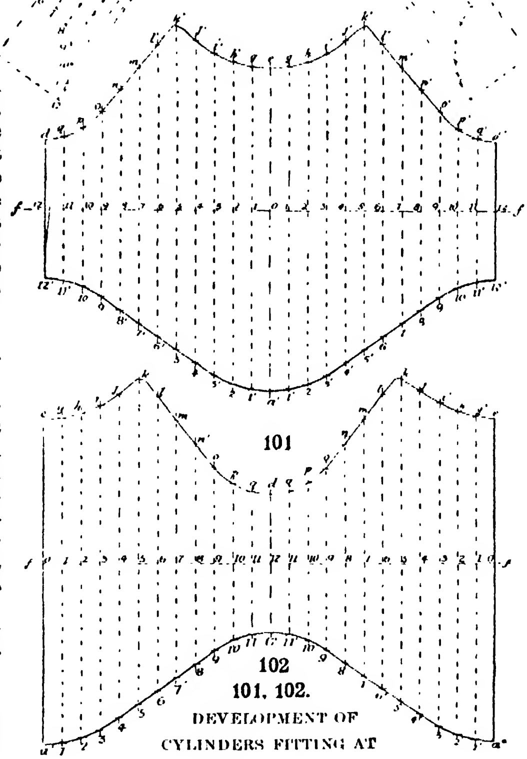
in **105.** The joint of the envelope has to be allowed for on the line *a*0′.

Quadrant of a Hemisphere. Fig. **107** shows the general construction involved in obtaining the development of portions of spherical surfaces, A representing a hemisphere in plan or end view, while **108** illustrates a plate giving one-fourth of its development.

A quadrant, *ab*, of the sphere **107** is divided into a considerable number of equal parts, and arcs are drawn from the centre line *ob*. The quadrant *obc* is a plan view of the elevation *oab*, to the left, the envelope of which is required. In **108** draw a line *od*, representing the bisection of a quadrant *od* in **107**, and divide it into the same number of equal parts as the quadrant *ab* has been divided into. The length *od* in **108** will then equal the length *ab* measured round the arc *ab*. On the points of division 1, 2, 3, 4, etc., in **108**, the widths of the plate will be marked. It would be troublesome to calculate all these separately, and it would not do to take chord measurements of any considerable length on the lines in **107**. But if, now, short chord lengths are stepped round the arc from the point of bisection *d* to *b* [**107**], as *d*, *e*, *f*, *g*, *h*, *i*, *j*, then the dimension *dj* taken at once will be a sufficiently accurate approximation to the arc length *db*. A straight line drawn from *j* to the centre *o* [**107**] will give corresponding lengths for the other arcs.



100. CYLINDERS FITTING AT EQUAL ANGLES



101

102

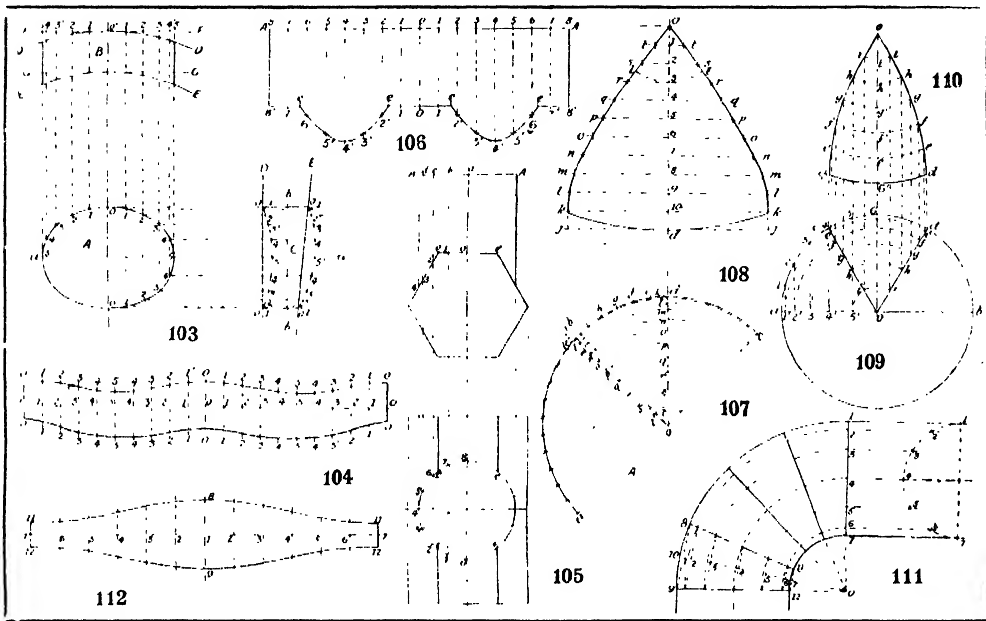
101, 102. DEVELOPMENT OF CYLINDERS FITTING AT EQUAL ANGLES

Development. To **108**, therefore, transfer the various lengths as shown, *d* to *jj*, 10 to *kk*, 9 to *ll* and so on. The intersections of these will give the edges of the plate on two sides. The other side is formed by a curve, the radius of which is arrived at by experience. Strictly, it should be struck from the centre *o*, with radius *od*; but though that would do for thin sheet metal, it would not be correct for plates of ⅜in. or ½in. thickness. The act of bending or dishing would shorten these curves. So the radius is made one and a half times the length *od*. If a piece be cut away, as indicated by the curve 3*ll*, this would be struck from the centre *o*, because the effect of dishing would be practically nil. A piece would be removed thus in building up globular buoys, or egg-end boilers, as this permits of making better jointing with a capping plate than as though the quadrant plates terminated at *o*. To the outlines in **108** the necessary amounts must be added all round for the overlap of riveted seams, from 2 in. to 2½ in., according to the thickness of the plates.

An Alternative Method. A variation on this is shown in the next problem [**109, 110**], where a spherical end of diameter *ab* is built of six plates, one of which is indicated at *ocd*. Divide a quadrant of the circle into a suitable number of parts, 1, 2, 3, 4, 5, 6. Erect perpendiculars from the line *ab* at 1′, 2′, 3′, 4′, 5′, *o*. From centre *o* draw arcs from these intersections, cutting the plate *ocd* in *e*, *f*, *g*, *h*, *i*. The developed plate is shown in **110**, above. The length *o*′6′ is equal to the length *o*6 in **109**, which of course is measured round the arc *a*6. The equal divisions *e*′, *f*′, *g*′, *h*′, *i*′ correspond with those in the lower figure measured round *a*, 1, 2, 3, etc., and the arcs corresponding are described from *o*. On these arcs the lengths of the arcs of the segment *ocd* [**109**] are laid off, *e*′*ee*, *f*′*ff*, etc., by measurement, or by the intersections of perpendiculars raised from *ocd* to cut the arcs of equal division, and the outlines of the plate are drawn.

Bends. We now show the way to strike the pattern for a quadrant bend pipe in four pieces. Fig. **111** is a plan showing the quadrant in four sections, uniting two pieces of straight pipe at right angles. Draw the semicircle 1 7, of the same diameter as the pipe, and divide it into any number of equal parts, 1, 2, 3, 4, 5, 6, 7. Project lines from these divisions to the line 1*o* at the beginning of the bend, and from

this line carry curves round, struck from the same centre as the bend, thus reproducing them on the horizontal line 9*o* at the base of **111**. Bisect one of the four divisions, 9 8, and draw the radial line 10*o*. Then draw a chord from 9 to 8, and similarly connect each of the other points where the curves cut the radial lines 8*o* and 9*o*. Now draw the centre line 7 7 of the pattern [**112**], and the transverse centre 8 9. With dividers set to the divisions that were first made round the semicircle 1 7 [**112**], step off a similar number of divisions from the centre, 1 to 7 at each end of **112**, the numbers corresponding in both figures. Draw vertical lines through these that of the tinman and zinc-worker in the sensible thickness of the plates used. Thin sheets may, for the practical purposes of development, be regarded as though they were without thickness. That is, the methods of geometry applied to these treat them as having length and breadth, but no more thickness than a sheet of paper, which can be bent indifferently in all directions. But this assumption would not answer in iron and steel plates having thicknesses ranging from, say, ¼ in. to 1 in. or more, or in the copper plates used for locomotive purposes, or for pipes and bends. In working these, the outer layers become extended, and the inner



103. Ellipse uniting boiler shell and firebox. **104.** Development of same. **105.** Cylinder fitting to hexagon **106.** Development of same. **107.** Hemispherical end **108.** Plates for same. **109, 110.** An alternative method to 10- **111.** Development for bend pipes. **112.** Plates for same

on which to mark the various widths of the pattern. Then take the length of each of the chords in turn from **111**, and transfer them to **112**. The longest is from 8 to 9, occurring on the outer radius of **111**, and in the centre of **112**. The shortest is from 11 to 12 on the inner radius of **111** and at the ends of **112**. In **111**, the line 10*o* serves as a centre line from which to take half the length of each chord, and in **112** they are transferred to each side of the centre line 7 7. Through the series of intersections thus obtained on **112**, the outline of the pattern is traced.

Difference in Sheets and Plates. The work of the boilermaker and plater, and that of the engineer's coppersmith, differs from compressed, while the middle layers suffer neither tension nor compression. It is these inner layers, therefore, that the marker-out considers in drawing developments, disregarding the stresses and distortions for the time being, just as he disregards the joint seams until the geometrical outlines have been determined. If his experience tells him that these extensions and compressions will influence the final sha so far as to distort the object, he has to ma allowance for them. Such an effect is term *drawing*, and it occurs when some kinds of wo are flanged or dished. How much to allow in a case can only be determined by previous expe ence of similar work of a similar class.

Continued

CIRCLES

Reduction of a Polygon to a Triangle. Theorem of Pythagoras and its Converse. Properties of Circles. Chord Properties. Angle Properties

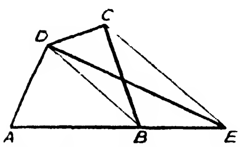
continued from page 4906

By HERBERT J. ALLPORT, M.A.

Proposition 33. Problem

To construct a triangle equal in area to a given polygon.

Let ABCD be any quadrilateral. Join DB. Through C draw CE ∥ to DB, meeting AB at E. Join DE. Then ΔADE will be equal in area to the figure ABCD.



Proof. The Δs DBC and DBE are on the same base DB and between the same ∥s DB, CE.

∴ ΔDBC = ΔDBE.

To each add ΔADB.

Then, figure ABCD = ΔADE.

By the same construction, any polygon can be reduced to a polygon equal in area but having the number of its sides one less than the original number. Hence, by repeating the process as often as is necessary, we finally obtain a triangle equal in area to the original polygon.

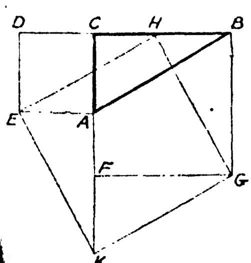
Proposition 34. The Theorem of Pythagoras

The sum of the squares on the sides of a right-angled triangle is equal to the square on the hypotenuse.

Let ABC be a right-angled Δ in which C is the right $\angle$. It is required to prove that

Square on AB = square on AC + square on BC.

On AC and BC describe the squares ACDE and BCFG. Produce CF to K, making FK = AC. Cut off BH = AC. Join HG, GK, KE, EH.



Proof. The Δs DEH, HBG, GFK, EAK are each easily seen to be equal in all respects to ΔABC. (*Prop.* 4).

∴ EH = HG = GK = KE.

∴ figure EHGK is a ▱ with all its sides equal. (*Exercises on Prop.* 24.)

Again, if the ΔGBH turns about the point G until GB coincides with GF, the ΔGBH will coincide with the ΔGFK, and will have turned through one right $\angle$.

Hence GH and GK are at right $\angle$s.

∴ since ▱EHGK has its sides equal, and its $\angle$s right angles, it is the square on EH, *i.e.*, the square on AB.

Now, it has been shown that

ΔEAK + ΔFKG = ΔEDH + ΔHBG.

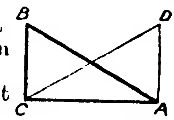
To each of these equals add the polygon EHGFA.

Then square EHGK = the squares ACDE, BCFG, *i.e.*, square on AB = square on AC + square on BC.

Proposition 35. Theorem

If the sum of the squares on two sides of a triangle is equal to the square on the third side, the angle contained by the two sides is a right angle.

Let ABC be a Δ, such that Square on AB = square on AC + square on BC.



It is required to prove that $\angle$BCA is a right $\angle$.

Proof. Draw AD $\perp$ to AC, and equal to BC. Join CD. Then, since AD = BC

the squares on AD, AC = squares on BC, AC.

But, squares on AD, AC = square on CD (*Prop.* 34),

and, squares on BC, AC = square on AB (*Hyp.*).

∴ square on CD = square on AB.

∴ CD = AB

Hence, the Δs ABC, ADC have the sides of the one equal to the sides of the other.

∴ Δs are equal (*Prop.* 7).

∴ $\angle$BCA = $\angle$DAC = a right $\angle$.

CIRCLES

Definitions. We have already, on page 4208, given definitions of a *circle*, its *circumference*, *centre*, *radius*, and *diameter*; an *arc*, and a *semicircle*.

A *chord* of a circle is a straight line joining any two points on the circumference.

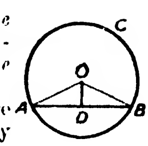
A *segment* of a circle is the figure bounded by a chord and one of the arcs into which it divides the circumference.

An *angle in a segment* is an angle formed by two straight lines drawn from any point in the arc of the segment to the ends of the arc.

Proposition 36. Theorem

The straight line which joins the centre of a circle to the middle point of a chord is perpendicular to the chord.

Conversely, the straight line drawn from the centre perpendicular to a chord bisects the chord.



Let ABC be ⊙ whose centre is O, and let AB be any chord.

(i.) First, let the straight line OD be drawn from O to D, the middle point of AB.

It is required to prove that OD is $\perp$ to AB.

Proof. Join OA, OB. In the Δs ADO, BDO, AD = BD (*Hyp.*),

OD is common,

OA = OB, since they are radii.

∴ $\angle ODA = \angle ODB$ (*Prop.* 7).

∴ each is a right $\angle$ (*Def.* 8),

i.e., OD is $\perp$ to AB.

(ii.) Again, let OD be drawn $\perp$ to AB. It is required to prove that OD bisects AB.

Proof. In the *right angled* $\triangle$s ADO, BDO,

Hypotenuse OA = Hypotenuse OB,

OD is common.

∴ $\triangle ADO = \triangle BDO$ (*Prop.* 20).

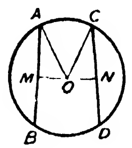
∴ AD = BD.

Corollary 1. *The straight line which bisects a chord at right angles passes through the centre.*

Corollary 2. *A straight line cannot cut a circle at more than two points.* For it has been proved that if the straight line is cut by the ⊙ at A and B, and OD is drawn $\perp$ to AB, then AD = BD. Hence, if the ⊙ cut the straight line at a third point E, DE would also be equal to DB, which is impossible.

Proposition 37. Theorem

Equal chords of a circle are equidistant from the centre. Conversely, chords which are equidistant from the centre are equal.



Let AB, CD be chords of a ⊙ whose centre is O. Draw OM, ON $\perp$ to the chords.

(i). First, let AB = CD.

It is required to prove that AB and CD are equidistant from O, *i.e.*, OM = ON.

Proof. Join OA, OC. Since OM is $\perp$ to AB,

∴ OM bisects AB (*Prop.* 36).

Similarly, ON bisects CD.

But AB = CD (*Hyp.*).

∴ the halves of these lines are equal,

i.e., AM = CN.

Then, in the *right angled* $\triangle$s OAM, OCN,

Hypotenuse OA = Hypotenuse OC,

and side AM = side CN.

∴ $\triangle$s are equal (*Prop.* 20).

∴ OM = ON.

(ii.) Again, let OM = ON. It is required to prove that AB = CD.

As before, it can be proved that AM and CN are the halves of AB and CD respectively.

Also, in the *right-angled* $\triangle$s OAM, OCN,

Hypotenuse OA = Hypotenuse OC

and OM = ON.

∴ $\triangle$s are equal.

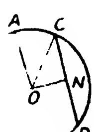
∴ AM = CN.

∴ their doubles are equal. *i.e.*, AB = CD.

Proposition 38. Theorem

Of any two chords of a circle, the one which is nearer to the centre is greater than the one more remote. Conversely, the chord which is greater is nearer to the centre than the less.

Let AB, CD be chords of a ⊙ whose centre is O. Draw OM, ON $\perp$ to the chords.



(i.) Let OM be < ON. It is required to prove that AB is > CD.

Proof. Join OA, OC. Then, as in Prop. 37, it can be shown that M and N are the middle points of AB and CD.

Now, since $\angle AMO$ is a right $\angle$

Square on AM + square on MO

= square on AO (*Prop.* 34)

= square on CO

= square on CN + square on NO (*Prop.* 34)

But, square on MO is < square on NO (*Hyp.*).

∴ square on AM is > square on CN,

i.e., AM is > CN.

∴ AB is > CD.

(ii.) Let AB be > CD. It is required to prove that OM is < ON.

As before, we have

Square on AM + square on MO = square on CN + square on NO

But AM > CN, since they are the halves of AB and CD.

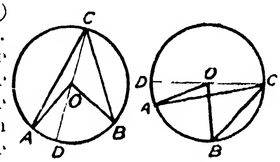
∴ square on MO is < square on NO,

i.e., MO is < NO.

Corollary. *The greatest chord of a circle is the diameter.* For, its distance from the centre is less than that of any other chord.

Proposition 39. Theorem

The angle at the centre of a circle is double of the angle at the circumference, standing on the same arc.



Let ABC be a ⊙ whose centre is O. Let AOB be the angle at the centre and ACB an angle at the ⊙ce which stand on the same arc AB.

It is required to prove that $\angle AOB$ is double of $\angle ACB$.

Proof. Let CO cut the ⊙ce again at D.

Then, since OA = OC,

$\angle OAC = \angle OCA$ (*Prop.* 5).

∴ $\angle OAC + \angle OCA$ = twice $\angle OCA$.

But $\angle OAC + \angle OCA = \angle DOA$ (*Prop.* 14)

∴ $\angle DOA$ = twice $\angle OCA$.

Similarly, $\angle DOB$ = twice $\angle OCB$.

Adding these results in Fig. 1, and taking their difference in Fig. 2, we get

$\angle AOB$ = twice $\angle ACB$.

NOTE. The proposition is true whether the arc AB be greater than, equal to, or less than half the ⊙ce.

If the arc AB is *greater than* half the ⊙ce the $\angle AOB$ is *reflex*, *i.e.*, greater than *two* right $\angle$s. Hence the $\angle ACB$ is greater than *one* right $\angle$.

If the arc AB is *equal to* half the ⊙ce, AB is a diameter, and the $\angle AOB$ = two right $\angle$s. Hence the $\angle ACB$ is = a right $\angle$.

If the arc AB is *less than* half the ⊙ce, the $\angle AOB$ is less than *two* right $\angle$s. Hence the $\angle ACB$ is less than *one* right $\angle$.

We have, therefore, the following important corollaries.

Corollary 1. *The angle in a semicircle is a right angle.*

Corollary 2. *The angle in a segment less than a semicircle is obtuse, and the angle in a segment greater than a semicircle is acute.*

Continued

RUBBER

Discovery of the Rubber Tree. Erasers and Macintoshes. Vulcanisation. Methods of Collecting and Preparing Rubber. Cultivating the Trees

Continued from page 1929

INDIA-RUBBER is derived from the laticiferous juices of certain tropical and sub-tropical plants. The honour of making this product known, and of tracing its real origin, belongs to two Frenchmen, Charles de la Condamine, a scientist, and Fresneau, an engineer. La Condamine was sent by the Paris Academy, in 1731, on a scientific expedition to the equator; whilst in Peru and Brazil he, in 1736, sent to the Academy some rolls of a blackish, resinous mass, known under the name of *caoutchouc*. He reported that "in the forests in the province of Esmeraldas grows a tree called Hevé by the natives; when the bark is slightly cut a white, milk-like fluid runs out, which hardens in the open air and becomes black. . . . . In the province Quito linen material is covered with this resin and is then used like oil cloth. The same tree grows on the banks of the Amazon River and the Mamas call the resinous fluid 'cahuchu.' They make shoes of it, which are waterproof, and when smoked have the appearance of leather; they also cover moulds made from earth and shaped like bottles with the material, and when the resin is dry the mould is broken up and removed through the neck, and thus an unbreakable bottle, useful for preserving all kinds of liquids is obtained."

The French botanist, Fuset-Aublet, described the caoutchouc tree in his work on the flora of Guiana, in 1728, and gave it the name of *Hevea guyanensis*. The *Urceola elastica* was found by James Harrison, and in the forests of Brahmaputra, in Assam, Roxburgh discovered the *Ficus elastica*. Later, Coffigny described a plant of the jasmine species, growing in Madagascar, and yielding a product not unlike caoutchouc.

The Origin of India-rubber Erasers. Later, in the year 1786, Herissant and Macquer succeeded in dissolving the resins in turpentine, pure ether, and Dippel's oil, suggesting at the same time that the gum solution should be used for making medical probes and small tubes such as are used in laboratories. About this time Priestly drew attention to the use of caoutchouc, and recommended it for effacing pencil marks. Accordingly, small cubes were introduced for this purpose, to which the name of "india-rubber" was applied, and this name has been retained to the present day.

From 1780 to 1820 various chemists studied the material. Grossart made known the most convenient way of making bottles, tubes, and other articles out of Brazilian caoutchouc by softening strips of suitable shape in ether, which were then rolled round a spindle, being finally bound up with rope; in drying the surfaces united, thus giving the article the desired shape.

Solutions of india-rubber were tried by various investigators for rendering cloth waterproof but it was not until the year 1823 that Charles Macintosh, by dissolving caoutchouc in benzene, laid the foundation of the waterproof industry, which has taken the name of the inventor. There were many difficulties, however, still to be overcome; the material was not easy to manipulate, dissolved but slowly, and did not readily take the desired shape. These imperfections were partially remedied in 1836, when Thomas Hancock found that caoutchouc cut into small strips and energetically kneaded under the influence of heat became inelastic but tough, and could then be pressed into any desired form. This gave a remarkable impetus to the industry. Its existence, however, would still have been very precarious had it not been for an opportune invention Natural caoutchouc has the great defect of being extremely sensitive to changes of temperature. Under ordinary conditions it is very adhesive and sticky; heat renders it pitchy, when it gives off an unpleasant odour; cold, on the other hand, causes it to become hard, and to lose its elasticity. It can readily be imagined, therefore, that a waterproof garment which split and cracked in cold weather and became sticky and odoriferous under the action of the sun's rays could hardly be considered satisfactory. These disadvantages, therefore, at one time quite imperilled the progress of the india-rubber industry.

The Discovery of Vulcanisation. It was in the year 1839 that an American, Charles Goodyear, succeeded in solving the problem after ten years of energetic research. His process consisted of subjecting a mixture of caoutchouc and finely powdered sulphur to a high temperature, the caoutchouc being thereby rendered capable of remaining elastic at both high and low temperatures. The term *vulcanisation* was given to this process and caoutchouc thus treated is called *vulcanised rubber*.

From the announcement of this invention and during the next twenty years great strides were made in the production of rubber articles, fresh discoveries and improvements following quickly upon one another. Among these were: Hancock's method of vulcanising in a sulphur bath, and the use of carbon bisulphide for dissolving caoutchouc, discovered by Parkes, who also patented the process of vulcanising by immersion in a bath of chloride of sulphur, the so-called *cold vulcanisation*. The use of alkaline sulphides was proposed by Gerard for vulcanising thin goods, and a further discovery by Goodyear resulted in the production of hard rubber goods, or ebonite, by increasing the amount of sulphur before vulcanisation. Finally, Hancock patented a process of moulding rubber goods which formed the basis for the production of a great variety of objects.

The regeneration of vulcanised rubber has yet to be perfected, being still an unsolved problem, although of late years great improvements have been made in this direction.

The Plants that Yield Rubber. Rubber-yielding plants embrace a large number of trees, shrubs, lianas, and several kinds of grass, growing in the tropical countries. The juice-bearing vessels are situated in the interior rings of the bark and send numerous branch veins in an outward direction, which end near the surface;

more rarely they penetrate inwardly to the pith. It is maintained that after the plant has reached a certain age the hydrocarbon which constitutes india-rubber is no longer necessary to its life; but the opposite view is also held by some, namely, that it affords nourishment to the plant. Upon an incision being made in the bark of a rubber-producing plant a milky fluid flows out, which is called the *latex*. By suitable treatment the microscopical globules suspended in the fluid unite to form a more or less solid substance, india-rubber, or, if the latex be allowed to stand, these globules rise to the surface, like the cream on milk. The latex from rubber trees is a slightly-coloured liquid having the density of cream; it will mix with water but not with naphtha or other solvents of india-rubber. Its specific gravity varies from 1·02 to 1·41, whilst that of caoutchouc lies between 0·93 and 1·03. The percentage of pure rubber in a latex varies considerably; the best, that from the Para tree in Brazil, contains 32 per cent., together with 12 per cent. of albuminoid and mineral constituents, and 50 per cent. of water.

All plants yielding a milky juice do not contain rubber; there are a large number of such growing in temperate climates—for instance, the nettle, poppy, lettuce, castor oil plants, and fig-trees—which cannot be considered as rubber yielding plants. In fact, the rubber-producing zone may be said to consist of a belt 500 miles wide encircling the globe at the equator. A moist, warm climate, that is to say of a temperature of 80° to 105° F., and an average rainfall of about 80 inches per annum, are the general conditions necessary for the production of india-rubber plants of commercial value, and such prevail within this region.

The Four Chief Orders of Rubber Plants. Rubber plants of various species are found in different parts of this zone, but they belong chiefly to four botanical orders, the *Euphorbiaceæ*, the *Artocarpeæ*, the *Apocynaceæ* and the *Asclepiadeæ*. Besides the nature and age of the plant, its surroundings, the soil, the season, and even the hour of collecting, affect the quality and quantity of the latex. The following are the chief rubber-yielding plants and the districts in which they grow. To take the *Euphorbiaceæ* first, the *Hevea brasiliensis* [1], a tree attaining a height of from 70 to 100 ft., and growing in Brazil, Para, and Venezuela, yields the purest and most esteemed commercial rubber, generally known as Para rubber. This is not the tree originally discovered by La Condamine and Fresneau, which only yields a poor, resinous product. Then the *Manihot glaziowii* of Ceara [2], which supplies a well known brand of rubber known as "Ceara scraps." This tree grows on dry, stony soil, and will stand a prolonged drought. The *Hevea*, on the other hand, requires a low-lying well-watered ground.

The two most important rubber plants belonging to the *Ulmaceæ* (a kind of the *Artocarpeæ*) are the *Castilloa elastica* [3] and the *Ficus elastica* [4], the former ranking foremost amongst the Mexican and Central American rubber trees. The *Ficus elastica* abounds in Eastern Asia and Oceania, but is only occasionally met with in America and Africa. As a hothouse and ornamental plant, a variety of this species is well known in Europe, where it thrives as long as it is protected from the frost. The *Artocarpus*, or *bread tree*, also belongs to this order. It is found in Burma and Assam, and yields a viscous latex which is used by the natives for making bird-lime. The tree grows to a height of from 50 to 70 ft., and its fruit constitutes a very nourishing food.

The African Rubber Trees. The order of *Apocynaceæ* includes a large number of rubber-yielding plants. The *Landolphias* [5], of which there are many varieties, are a species of this order, and are very good rubber-yielding lianas found throughout the tropics of Africa and Madagascar. The *Hancornia*, another member of the same family, is a latescent shrub growing in certain parts of South America. It supplies a very excellent brand known as *Mangabeira* rubber. The *Kickxia*, renamed *Funtumia*, is an African rubber tree, occurring on the west coast from Sierra Leone to the Congo State, and in the hinterland. It has only been recognised as a valuable rubber-yielding plant since 1894. It grows to a height of from 50 to 60 ft., with a straight, circular trunk, and has the further advantage of being adaptable for transplantation. The *Carpodinus* and *Clitandra* are two creeping plants also belonging to this order, and are indigenous to the Congo State. They yield *root-rubber*, so-called owing to its being procured from the main root branches.

Rubber plants belonging to the *Asclepiadeæ* order are not of great importance, and do not call for any special mention.

The vascular system of all rubber plants is not exactly the same. It is especially well developed in the *Ficus* species. The age at which different rubber producing plants bear also varies greatly; thus, it is 15 or 20 years before the *Hevea brasiliensis* is ready to be tapped, while the *Manihot* and the *Urceola* yield well at 10 years. The quantity of rubber in the latex fluctuates with certain conditions: if the soil be too damp and moist, it becomes watery, while a dry season renders it richer, but more difficult to collect. It often reaches 40 per cent., but 15 per cent. is regarded as the lowest workable figure.

There is no doubt that in certain districts the desire to obtain rubber at all costs has led to acts which can be described as nothing short of wanton waste. In the Congo State in particular the collection of rubber has been pursued with the utmost barbarism and rapacity and disregard of future productiveness of the trees; it is to be hoped that a more rational state of affairs will be speedily introduced into this district, which is probably the richest caoutchouc producing land in the world. Recent reports from South American rubber districts are on the whole satisfactory, the tendency being to more rational management of caoutchouc production, but the uncertain state of political affairs in many South American States often renders the business precarious.

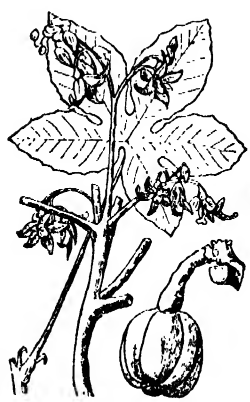
How the Latex is Collected in South America. The collection of the latex requires care and experience. There are two recognised methods by which it is obtained from the rubber trees. One by felling the trees, and the other by tapping—that is, making incisions in the bark. The former gives the larger yield at the time, but, as a general practice, is extremely wasteful, and is only permissible when the tree would in any case decay after the first tapping, and secondly when a virgin forest requires thinning out. The best method of tapping is that employed on the Amazon. The *seringuerio* or *cauchero*, as the collector is called, starts at dawn, his implements consisting of a small, short-handled axe, called a *machado*, a pail, and drip tins. The stems of the trees selected for his operations having been carefully cleaned, and the ground round about swept, he proceeds

to make about twelve incisions in every tree; the cuts must be deep enough to allow the latex to flow, but not severe enough to damage the trees. Making vertical cuts, one below another, from a height that can be reached down to the ground is the simplest and easiest way, but some collectors prefer to make V-shaped or curved incisions. Careful tapping does not appear to hurt the *Hevea* tree, but if carelessly and irregularly cut, the yield of latex diminishes after the third year, and eventually ceases altogether. The seringuerio generally selects from 100 to 150 trees, which he divides into three sections, upon one of which he operates each day. The best season for collecting in Brazil is from the end of August to the beginning of January, and about twenty tappings are made every year; more would tend to impoverish the trees. A tin cup is fixed by means of clay under each incision to receive the latex, the quantity of which varies with the season, whether wet or dry, and according to the age of the tree; 150 trees tapped 20 times a year are calculated to yield about 14 cwt. of crude rubber. Having collected his rubber, he brings it to Manaos or Para, or disposes of it through an agent.


1. HEVEA BRASILIENSIS

Collecting in the Old World. English companies have of recent years started collecting in Brazil, but with what success is not yet evident. The above method of tapping, with slight variations, is in vogue throughout South America. The Central American rubber plant, *Castilloa elastica* [3], does not require such a large incision; in fact, instead of a cut a hole merely is made in the bark. A variety of methods are employed in Africa, and in many parts the natives have no hesitation in sacrificing the trees so long as they procure the rubber. In collecting caoutchouc from the *Ficus* species in Asia, care is exercised in making incisions to cut just down to the cambium layer, but not to penetrate the wood, so that the wounds heal as soon as possible. The best months for collecting in India are February and March, and also in August, for although the quantity of latex obtained is not so large, it is very much richer during these months. The methods adopted in Australia are to a certain extent similar to those of Asia, but unless the natives are supervised they cause needless destruction; for instance, a liana a foot or so thick will be cut into pieces, which are then held over vessels to receive the latex, the flow being accelerated by heating. It can easily be understood that indifferent tapping causes an admixture of sap with the latex, which is prejudicial to the quality of the rubber. This, therefore, also points to the necessity of conducting the operation carefully, apart from the preservation of the tree. Special knives are now made for the purpose of tapping the various kinds of rubber trees.

Preparing the Caoutchouc. Having collected the latex, the next operation is to separate the caoutchouc, which is effected by coagulation in many ways. For the preparation of the Para rubber, on the Amazon, the tins containing the collected latex are emptied into a vessel, or if the trees are conveniently situated, the entire collection is placed in a tank until the coagulation process is ready to be carried out. A fire having been lighted in a specially constructed oven, palm nuts are added to produce a thick smoke, on the lower Amazon, while in other districts the smoke from a wood fire is considered sufficiently thick. Taking a long wooden *form*, or paddle, the cauchero dips the blade into a pail of latex, and then exposes it each side alternately to the smoke; the moisture in the latex is evaporated by the heat, and the first thin layer of rubber is formed; the wooden instrument is again dipped in the latex, and the process repeated until a sufficiently thick layer of caoutchouc is obtained. The thin coat is removed from the form by cutting it open with a knife, and in this way a workman can make from four to five pounds of rubber in an hour. The usual lumps, not unlike loaves, in which lower Amazon rubber comes on the market are termed *biscuits*, which are still moist when removed from the forms, and have to be dried two or three days in the sun. Smoking in this manner is undoubtedly tedious, but taken in conjunction with the excellent quality of the latex, it produces the finest rubber in the world, known


2. MANIHOT GLAZIOWII


3. CASTILLOA ELASTICA


4. FICUS ELASTICA


5. LANDOLPHIA OWARIENSIS

as *Para rubber.* The action of the smoke is antiseptic, thus preventing fermentation and decomposition. Para rubber of a less fine quality, known as *Para grossa*, *Para entrefina*, and *negro heads*, are prepared from the residues of caoutchouc which adhere to the wounds. They are formed into flat balls, and these are dipped into fresh latex and smoked. In outward appearance they resemble fine Para, but if cut open it is apparent that the rubber is of less value, being dirty and incompletely coagulated.

Coagulation by Boiling. Boiling the latex is another means of coagulation employed in Central America for the latex from Castilloa trees. The crude rubber collects on the top, and is then pressed. This method, however, is defective, as pressing is not sufficient to remove all the moisture, so that the rubber is interspersed with bubbles filled with a thick, green fluid. Improved methods of coagulating this latex have been introduced in Mexico, sea salt being employed, since the rubber is much cleaner and nearly as elastic as that from Brazil. For coagulating the latex of the *Funtumia*, the African rubber tree, the boiling process appears to be the most suitable, and entails but little labour. The latex is first mixed with water, then boiled, and afterwards thrown into a vessel containing cold water; the rubber, which has now acquired some consistency, is pressed, and drawn out like a sausage; it is then cut up, and dried in the shade. It is then ready to be shipped. The root rubber of South Africa from the *Carpodinus* and *Clitandra* species is obtained by a similar method. The roots are cut into pieces about eight inches long, and placed in the sun for five or six days; they are then immersed in water for ten days, beaten with sticks, and boiled in water, finally being beaten again. The product, however, is of an inferior quality, frequently containing as much as 50 per cent. of foreign substances. Improved mechanical means are being tried for the purpose of separating the rubber more perfectly.

Coagulation by Natural Heat. A very primitive way of coagulating the latex by natural heat employed by certain East African tribes consists of merely tapping the trees and allowing the latex to flow on the ground, where its moisture is quickly absorbed by the hot, dry soil; needless to say, this rubber is largely contaminated with vegetable and mineral impurities, and the nitrogenous substances retained in the rubber render it soft, sticky, and odoriferous. Another curious method by which the natives of East Africa obtain rubber consists of smearing the latex as it runs from the trees over their own bodies; when dry, it is peeled off and rolled into balls.

Ceara Rubber. *Ceara* rubber, obtained from the latex of the *Manihot glaziowii* [2], is collected by the following process, which is also employed in West Africa and India. The ground around the tree is cleared and covered with banana leaves. As the latex is much thicker than that of the Para rubber tree it flows out slowly, and in many cases coagulates before it reaches the ground. After drying on the trees for two or three days, it is removed and formed into balls. Ceara rubber is of good quality, but liable to fermentation unless stored in a cold, dry place; that which is collected from the ground often contains impurities. When tapping *Ficus* trees in India, mats made of thin strips of bamboo are employed in a similar way for catching the latex. These are moved about on the ground by boys until quite covered over by the dripping latex. After forty-eight hours a skin sufficiently tough to be pulled off is formed, and this is then dried. The latex that coagulates in the cuts is of a reddish brown colour, and after pieces of bark and the impurities have been removed, the dried rubber is pressed into cubes of a hundredweight each, which are wrapped in white cloths for transport. Crude rubber has recently been placed on the market in the form of blocks, termed *block rubber*, and in this convenient form it finds great favour.

The latex of the *Hancornia* is coagulated in Bahia by adding an equal quantity of water, and, after allowing the mixture to stand, skimming off the upper layer consisting of raw rubber, which is dried, and is then ready for sale. This method is also employed in some parts of Central America and Assam, though it is not to be recommended, since a certain quantity of uncoagulated latex remains; the rubber itself, however, is of a good, strong quality. Another similar process is used by the natives of the Congo for coagulating the latex of the *Landolphias*. The latex is conducted from the incision into a bottle, and mixed with four or five times its quantity of water; the caoutchouc rises to the top on standing, and the lower watery layer is run off from the bottom. The caoutchouc is then further coagulated, kneaded, and dried, but it is very liable to fermentation, as it contains too much water, and also nitrogenous matters.

Coagulation by Chemical Agents. Various chemical reagents have been suggested from time to time. Strauss recommended the addition of a solution of alum, which brings about immediate coagulation, but it has the great defect of causing the rubber to speedily lose its elasticity. Both sulphuric acid and salt also effect rapid coagulation, the antiseptic properties of the latter giving it an advantage over the acid, which it has accordingly superseded in son[e] districts. Chemical treatment is chiefly utilised in America and Africa. In addition to these reagents, soapsuds have been tried in Peru f[or] coagulating the latex from the *Hancornia*. Abo[ut] half a pound of soap dissolved in two pails of wat[er] is sufficient for 65 lb. of latex; the liquids are thoroughly agitated together; when coagulated, the rubber is removed in the form of a block.

Alcohol also gives very good results in effecting coagulation, but is too expensive.

Certain vegetable juices and infusions containing an organic acid are employed in Madagascar and parts of South America, but these offer no special advantages.

Use of Machinery. Coagulation by machinery is now practised in India and Ceylon. The latex is first freed from all impurities by passing it through a centrifugal strainer, and it is then run into a settling tank until a sufficiently large quantity has accumulated for further treatment. Meanwhile mechanical stirrers, with which the tanks are provided, keep the latex thoroughly mixed with the preservatives ammonia and formalin; by this means it can be stored for several days. The latex is then passed through the smoking machine, which is an arrangement whereby, in running over a series of plates, it is exposed to the influence of smoke from a fire made from wood steeped in creosote. Finally the latex is coagulated with acid, either in a special appliance or in ordinary settling tanks. Rubber prepared in this way is, of course, infinitely to be preferred to the frequently greatly contaminated product resulting from native methods in Africa and parts of America.

Cultivating Rubber Trees. By far the largest proportion of rubber produced at present is obtained from *naturally grown* trees. The *cultivation* of rubber-producing plants has, however, been vigorously taken up of late years, and large areas have been planted with rubber trees, especially in India, Ceylon, the Malay Peninsula, and the French Colonies. Small plants have been found to give very satisfactory results. Hevea plants, for instance, are grown in nurseries until about 20 in. high; they are then cut off about 4 in. above the roots, and packed in a special way in cases. In this state they have undergone a six weeks' journey, and when planted out have only had a mortality of 2 per cent.

Seeds of the *Hevea brasiliensis* were obtained from the Amazon district some thirty years ago. These were propagated in Kew and the plants distributed to various botanical gardens in the Colonies. Ceylon succeeded best in the early cultivation, and as the transported plants grew and gave seed these were given out to planters. Ceara (*Manihot glaziowii*) and *Castilloa elastica* were also planted, the former being the favourite. Gradually, however, the claims of the Hevea were recognised, and the proportion of the other now existing or being planted is small. In 1898 alone about 750 acres were planted in rubber in Ceylon. This grew to 2,500 acres in 1901. At the present time it is estimated that over 100,000 acres are planted in rubber.

The Superiority of the Hevea. The selection of the most suitable kind of tree naturally depends upon the district, but certain species have advantages over others. The *Ficus elastica* is slow in growing, but its cultivation in India meets with good success.

The *Hevea brasiliensis* has been introduced into the Malay State with eminently satisfactory results, climatic conditions being here as favourable for its growth as in its home in Brazil, and about 90,000 acres have already been planted with this tree. The *Funtumia elastica* appears to be the rubber plant that is most suited for African cultivation, and in many districts it is to be preferred to the *Landolphia*, although it is maintained that it does not produce such good quality rubber. With the proper treatment, however, this could be improved. Its cultivation offers few difficulties; the seedlings are planted 16 ft. to 17 ft. apart after clearing the undergrowth, and need no further attention, which is very advantageous.

Given suitable soil and climate, the cultivation of the Hevea is simple. The seeds are either planted at stake—that is, planted in the spot to be occupied by the tree—or grown in nurseries, and then planted out. The number planted to the acre is 150 or upwards to 200. The tree requires good, deep soil, with plenty of water. It is generally considered that at least 80 in. per annum, with no very long dry season is the minimum. After the seeds or plants are put out, careful watch has to be kept that they are not destroyed by vermin or wild animals. The weeds are kept down—a somewhat expensive item—until the trees (about the third or fourth year) have grown large enough to check the undergrowth. Well-growing trees can be tapped in the fifth year. It is estimated that on the average a six-year-old tree will give ½ lb. of dry rubber; a seven-year-old, 1 lb.; a ten-year-old, 2 lb. to 3 lb.; and a sixteen-year-old, at least 5 lb. The cost of clearing, planting, and tending rubber until it is six years old is estimated at £20 per acre in Ceylon. In these notes Ceylon is only taken as a typical instance of what is going on in other tropical countries.

6. TAPPING THE RUBBER TREE IN THE EAST
(From a photograph by R. Hoffmann, Esq.)

Tapping. Tapping the rubber trees is conducted on the estates in a very regular manner. Care has to be taken that only the bark is cut and the wood of the tree left untouched. Various knives have been invented to perform this duty. The principal method now employed is to make a preliminary cut, either a spiral round the tree [6] or a less distance, or only a short, oblique cut. The bark at the foot of this cut is trimmed away every second day or so, the latex collected in a cup, mixed with latex from other trees, and then taken to the factory. Here it is allowed to coagulate, until the soft, spongy mass of rubber can be lifted out. It is then washed by hand or put through a regular washing machine. It is then dried thoroughly. Determined by the method which has been employed, this plantation rubber comes upon the market in either biscuits, sheet, crepe, or block rubber, the latter being sheet, which has been dried in vacuum, and while still hot and somewhat soft, pressed into a solid block. Such plantation rubber well prepared brings about 8d. per lb. more than fine Para, since it is much purer and drier. As rubber for manufacture, however, it has not commended itself to the makers, who consider it weaker than fine Para. [The drawings in this article are from "Rubber, Gutta-percha, and Balata," by F. Clouth. Maclaren.]

Continued

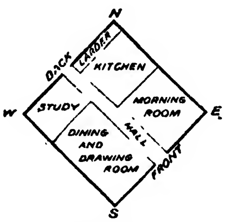
Continued from page 4864

THE BEST HOUSE TO LIVE IN

The Material of which a Healthy House is Made. Conditions of Perfect Sanitation. How Infection may be Averted. Isolation and Disinfection

By Dr. A. T. SCHOFIELD

A HEALTHY dwelling should stand on dry soil, should have light rooms, and be of cheerful aspect. There should be good ventilation, perfect drainage, abundant pure water, and dry foundation; walls, roof, and the corners of the house should be to the points of the compass. The living-rooms should face south and west; the working and breakfast rooms, stairs, and larders north and east; the bed-rooms north-east [4]. This gives the morning sun, and leaves them cool at night and in the day. All morning rooms should face east. Sick bed-rooms and nurseries should be south-east.



4. HOUSE BUILT TO FOUR POINTS OF COMPASS

Houses should not be back to back in close courts or alleys. Every house must have a space in the front and back at least equal to its own height. In temperate climates, the distance between two opposite buildings must be twice the height of the higher one.

In an artisan's house of four rooms in two storeys, the bottom floor is 9 ft. high, the top 8 ft. The front room has 150 sq. ft., the back room (scullery) 75 ft., the front bed-room 80 ft., the others 50 ft., with fireplaces in all.

For a healthy house, these conditions must be maintained:

1. The site, free from offensive made soil, must be covered with concrete.
2. The external walls thick enough to resist damp.
3. An efficient damp-proof course in all internal and external walls.
4. Weather-tight roof.
5. Good light and ventilation in all rooms and passages.
6. Good, airtight sewerage.
7. Pure water, well stored.

Houses should not be too crowded; 48 six-roomed cottages to the acre is enough, holding 240 people. In model dwellings there are over 1,000 to the acre.

Basements. In basements the drainage must be good, and the sewage not under the house. If built on an old brickfield, all pits and hollows near must be drained; if on made earth, the soil should have stood for two years before being built upon.

6. ROLLED JOINTS

Basements must either have a concrete floor 6 in. to 8 in. thick, or one of puddled clay; if neither, then there should be 9 in. between earth and floor for ventilation, but this is the least desirable of the three.

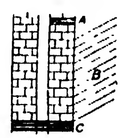
Notice the height of the subsoil water. There must be no foul sewer near. If the foundation for the walls is not good, a foundation must be put in for them, four times as broad as the walls.

There must be free ventilation under the floors, and it should be noted that iron gratings are better than perforated bricks. Concrete is a good protection against damp.

Houses are like sponges; they suck up all the gases out of the ground. The water and gases in the earth move in currents. There is a record of an empty beef tin being carried seven miles underground by the subsoil water.

Concrete serves as a floor. If wood is required, it need only be 3 in. above it. Wood-brick floors are best, or concrete for all basement rooms.

Walls. Walls should have broad footings after the solid earth has been reached. A damp-proof course must be inserted. There should be no earth against the wall. If there be any, the wall must be built hollow till above the earth, and two damp courses inserted there [5]. The moisture rises from the sides of the walls as well as the base, also from soil splashings. A damp course may be made in the wall of slate, stone, vitrified slabs, glazed bricks, or asphalte rock that does not squeeze out with weight.



5. POSITION OF DAMP COURSES
a. Upper course *b.* Ground against wall *c.* Lower course

Bricks are made of clay, which is alumina and silica; of marl: of the same substance mixed with lime, and of loam, a light, sandy clay. A brick should weigh seven pounds, and can hold one pint of water. Mortar should be one part lime and three parts clean sand (no sea shells) and fresh water—never salt.

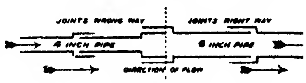
If stone be used, sandstone of various colours, according to the iron in it, is good; or limestone. Portland stone is also good; bathstone is soft and crumbly. Magnesia limestone is really consolidated Epsom salts. The Houses of Parliament are built of this.

In 100,000 bricks there are 10,000 gallons of "building water." Each brick will absorb 1 lb. of water. In old houses all this has evaporated, and the pores are full of air; in new ones much is retained. Water keeps the walls too cold, and the air condenses in the rooms.

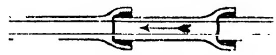
Water glass (silicate of potash) renders soft stone impervious to damp and decay. Interwalling bricks, etc., can be "enamelled" with it. To find if the walls are dry enough, pick out bits of mortar. These should not have above

5 per cent. of water in them. In building, English bond is better hygienically than Flemish. In the latter, whole bricks (not bats—half bricks) should always be used for "headers."

A 9 in. wall is not enough externally to prevent weather from penetrating "header" bricks. It must be 14 in., or more if of stone. This is important, as an even temperature in the house depends on the thickness of the walls.



7. DIMINISHING PIPES



8. STRUTT'S PIPES

On the wettest, or "weather" side of the house, there should be slate or pitch or Portland cement; or the wall may be tiled or rough cast, or slated with a cavity. A cavity wall does not interfere with natural ventilation.

9. MANHOLE

Concrete is good for walls, and so is terra cotta. Party walls should be 9 in. thick, and carried 15 in. above the roof. Bathstone facings and stucco are both bad, and constantly require painting. The law is that a house two storeys high (25 ft.) must have a minimum thickness of one brick (9 in.); if over 25 ft., then 1½ bricks for the first storey, and one brick after; if over 35 ft., two bricks for two storeys, and 1½ bricks for the rest; if over 50 ft., then 2½ bricks for the first story, two for the next, 2 and 1½ for the others. Modern American buildings of steel, filled in with stone and brick, alter all these calculations.

Inside walls can be glazed with tiles, plastered, covered with impervious paint or washing paper, or a new sheet of tin painted on one side, which is admirable for pantries, bath-rooms, etc. Ceilings are made of lath and plaster, to deaden the sound. Floors are tongued and grooved, or caulked. Carpets should be in squares, and not fit into corners.

The Roof. The slates of a roof are laid on boarding covered with felt. "Countess" slates are 20 in. by 10 in., and are best with a 3-in. overlap, a lead gutter, and cement joints round the chimney stacks. All channels should be of sheet lead. Avoid nails in lead roofwork, because galvanic action sets up. Have rolled joints to allow expansion [6].

Rows of houses should run north and south, and there should be no borrowed lights. Theoretically the kitchen is always best at the top of the house. Hinged windows are better than those built on the sash principle, and can be more easily cleaned outside.

All closets should be separate rooms, well ventilated into the external air. They should be in the external wall with a window 2 ft. square, and be supplied with a separate cistern and ventilated with air bricks. This also applies to the larder. The kitchen should be well ventilated into the air. The coal-cellar should be cut off from the house on account of the gases given off. There must be no dry rot in the wood for there is no cure for this when it has once set in. Gas dry meters should be fitted with Stott's gas regulator to avoid flaring and to save the gas.

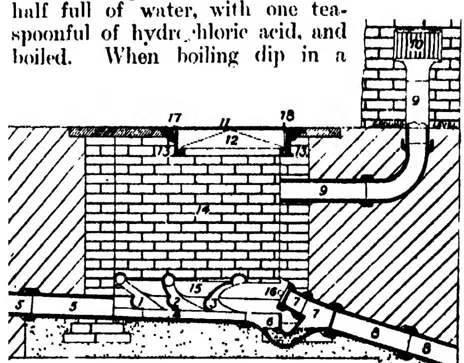
No water-pipes must run on outside walls unless protected with felt. Where necessary taps should be marked "Main" or "Cistern." In buildings generally avoid all porous absorbent materials—there should be no damp anywhere.

Furniture. In rooms the style of furniture is getting more Oriental. Woollen hangings should be avoided; they encourage dirt. A velvet boudoir in Mayfair nearly caused the death of a well-known doctor. Plainness and cleanliness should be insisted on in towns, and while the bareness of a hospital ward is undesirable all needless hangings and other dirt traps should be avoided. The basement, especially, should be kept clean and free from hoarded rubbish.

Arsenic is still found in some wall-papers not necessarily green, as well as in green lamp-shades, etc.; but it is only injurious when the dust is brushed off and particles are allowed to fly about in the air. Before now a pair of gloves dyed with arsenic have caused apparent "hay fever"—in reality, symptoms of poisoning. If the health deteriorates without apparent cause it is probably due to sewer gas—less probably to arsenic. Glazed washing paper or paint on all walls is, of course, the best kind of covering.

Any articles supposed to contain arsenic can be tested at a moderate cost, or perhaps free of expense, by the borough analyst of the borough or district council.

To test arsenic, four square inches of paper should be placed in a test tube half full of water, with one teaspoonful of hydrochloric acid, and boiled. When boiling dip in a bright copper or platinum wire. If it turns black, there is a quantity of arsenic. If it becomes covered all over in half an hour or less, there is a proportion of arsenic; if not covered there is none. Mere blotches do not count.



10. INSPECTION CHAMBER

1, 2, and 3. Side drains 4. Main drain open in inspection chamber 5. Main drain 6. Disconnecting trap 7. Inspection arm 8. Drain to sewer 9. Fresh air inlet 10. Grating niteh 11. Airtight cover 12. Condensing dome 13. Seal 14. Glazed bricks 15. Cement 16. Plug 17. Ordinary joint 18. Water joint automatically sealed by condensation

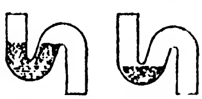
House Sanitation. A drain should be 4 in. in diameter; in large mansions it may be 6 in., and in public institutions 9 in.; but the smaller it is, the better the flow. It should be bedded in 6 in. of solid concrete so that if there should be a leakage or a fracture nothing can escape. It should never be carried, even with these precautions, underneath the house.

All branches or connections should join at an angle like a Y and not at right angles like a T. The drain must run from point to point in a straight line in true gradients, with an even fall, which should be 1 in 50 on an average, or 1 in 40 for 4-in. pipes, 1 in 60 for 6-in., 1 in 90 for 9-in. pipes. With the usual gradient the velocity of the flow is 3 ft. to 4 ft. per second. In a 4-in. pipe half full the flow is 8 cubic ft. every second, in a 6-in. 18, in a 9-in. 40.

The velocity of the current is the same if the pipe be full as if it were half full. The internal surface of the drain-pipe should be smooth, polished and round, with no ridges at the joints. The joints should be cemented and well wiped inside with one part of tar, one of sand, and one and a half sulphur. The ordinary socket joint, if well made in cement or bituminous rings and cement, is good. There must be no movable joints.

11. COMMON FORMS OF TRAPS

Diminishing pipes must be used when needed or the joint will come the wrong way [7]. Strutt's pipes, with rebate inside and perfect centring [8] are the best sort. All curves and bends should be avoided. If it has to be carried inside the walls an arch must be turned in the wall so that it does not press on the pipe. There must be an inspection manhole at every change of angle. A manhole should be 3 ft. 4½ in. by 2 ft. 3 in. with galvanised airtight iron doors, not stone [9], made airtight by a water seal. The manhole must be kept perfectly clean or it becomes a cesspool. A syphon trap into the sewer is best in the area with air inlet on the house side of trap.


12. TRAP SEALED AND UNSEALED

If all the closets are upon the ground floor, and there is no vertical soil-pipe, there can be two inlets in the air chamber—one for foul air and one for fresh. In the manhole itself the drain-pipes are open and are called "channel pipes." They are ½ in. or ¾ in. wide, and the side channels deliver above the base of the main drain, with a steeper gradient and joining at a Y angle [10].

The trap in a 4-in. or a 6-in. pipe is 4 in. wide. There should be a fall in all of 2 ft. to the water seal to give the water a "head." Longer systems may require more than one disconnecting trap.

Traps and Seals. It will be well here to describe exactly what is meant by traps and seals, as well as to understand the various sorts of closets. The leading principle of house sanitation is that there must be no communication between the house and the drainage. The earliest traps were syphon. The D trap was invented to improve them, and now we revert to some form of the syphon again [11]. The point is to have as few traps as possible. They all avert the flow and encourage stagnation of solids and decomposing water. The water seal gives them, of course, all their efficiency and consists of a certain amount of water which settles in the lowest part of the bend, and, filling the pipe, then cuts off the air on one side from that on the other. This seal [12] is generally 2 in. to 3 in. deep above the bend of the pipe. The water tends to dry up in summer if the drains are not used. All traps should have their inlet vertical to secure a good fall, and the outlet inclined. The inlet, also, must be higher than the outlet. The latter should be egg-shaped in section.

The trap should be ventilated on both sides to keep down any pressure of gas that might tend to force itself through the water. There should be a good raking arm kept hermetically sealed in disconnecting traps.

The water seal absorbs and gives off gases. When the pressure from the sewer is greater than the weight of water which constitutes the seal, the trap is forced by the gas and becomes useless. This often occurs in the higher parts of an extensive drainage system, as at Highgate and Hampstead. Sewer gas is constantly forcing the traps there, and the only course to relieve the pressure is free ventilation of the drains.

Closets. Solid matter from sewage cannot be forced back through the trap, but if air is mixed with the water, as when a trap is forced, so as to make bubbles, they burst, and particles of sewage are ejected into the air. Flooded traps will carry sewage back into the house.

Closets may be dry or on the water system; the latter are better. "Privys" and "middens" have no water. Water-closets are of two sorts: those without movable apparatus for retaining water in pan, and those with it. In the first kind we have long hoppers [13], short hoppers, and wash-outs. The long hopper is just a long cone, and is bad and dirty. The short hopper [14] is a short cone nearly vertical behind, with all the slope in front, and with or without a trap at the bottom. This, with a good flushing apparatus, is not bad. It is also made with a rim and of a bowl shape. The flush should allow 3 gallons down a 1¼-in. pipe with a fall from 6 ft. down the closet. The ordinary allowance is 2 gallons with a 4-ft. fall. No safes or overflows are needed with hopper closets, which are very good out of doors.

There should be concrete floors and a hinged seat, no back and no wood casing, but all of one piece of earthenware, and P or S traps throughout, jointed with cement to a 4-in. drain.

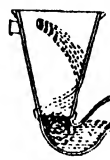
The disadvantages of all hoppers is that the contents are exposed and there is waste of water. The third form, the wash-out [15], has a shallow pool kept by a ledge in the pan, and a syphon trap below. It requires more than 2 gallons of water to carry contents over the edge

and through the syphon, and becomes soiled by splashes, the water in the basin being too shallow.

The "Dececo," or syphon closet [16], has deeper water in the basin; it is cleaner and needs more flushing; but it has the disadvantage that if slops are thrown down it, the water syphons out of both traps, and leaves it untrapped.

An improved Dececo, the Century closet [17], has a puff pipe that prevents syphoning by stopping the suction action; half the flush of water is not sent into the basin, but between the two syphons, thus sucking down the upper air.

The cistern should have a branch to the pan to fill up the water there as the cistern fills, if it is syphoned. The waste-preventing cistern is best with a syphon action so that a short pull starts it, and empties the cistern.

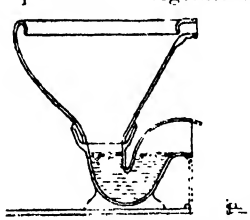


13. CLOSET, WITH LONG HOPPER

If the drain be indoors, and there are lead soil pipes, it is hard to make a good joint between lead and stone. Marine glue or a brass collar with asbestos and cement is best; or a brass socket can be fixed on the earthenware pipe with cement and gaskin. The lead pipe can be opened and the brass collar put inside and soldered firmly.

The second form of closet alluded to is with movable apparatus of some sort, and may be pan, valve, or plug:

The pan is largely used. but is now forbidden to be fixed. It has a dirty retainer and a D trap. The dirt decomposes in it, but no overflow is needed to the basin. Pipe 3 is in direct communication with the dirty trap [18]. The drinking water is drawn up (11) from the closet cistern. The container, of iron (8), gets inconceivably foul. The D trap (9) is the worst and most ineffective one known. The seal is often syphoned and ineffective.



14. CLOSET, WITH SHORT HOPPER

The valve [19] is not a good arrangement. It is water-tight, so that an overflow is needed in case of faulty action, and there is always a danger of water or foul air entering by the overflow. There is a trapped box under the valve.

The plug [20] plunges up and down and splashes badly. It must have a syphon trap below. If not held up a little time it catches the excreta as it is forced down and jams.

The Axis closet is another modification [21].

Jenning's side plug is an improvement on the short hopper. It holds more water in the basin and there is less splashing. The disadvantage of the plug and valve is that there is foul air below the plug. For large numbers, for use in camp or out of doors, a trough with syphon trap and automatic flush with reversed ball valve, which lets all out when full, is most sanitary and useful [22].

Slop closets must be used when flushing down by slops is insufficient. Automatic flushing is used when slops are not poured into closets but into a sink, and run into a three-gallon tipper which discharges automatically when full, either by the side of the closet and flushes it out, or into a trap, and passes out of doors [22].

The automatic flushing gully (in principle like a Dececo closet) is best out of doors for slops to discharge over, as it will not clog.

Syphonage. One word about syphonage, which is such a trouble in ill-managed closets and traps. It always occurs when the water fills the full bore of a pipe, or it may occur by suction and momentum, when there are three or four closets one above another emptying down the same pipe. It is obviated by the ventilation of the soil pipe and by an anti-syphon pipe, 2 in. in diameter, inserted into the crown of the trap of all closets and sinks except the highest. This entirely stops all suction.

The soil pipes should be of lead, 4 in. in diameter, and 8 lb. to the square foot, and should be continued to 6 in. above the roof with a wire cover. Iron is rougher and cheaper, but if much hot water is poured down, the iron twists and wears out.

The pipe should be drawn lead without seam and wiped joints. The joints are made by a tampon of wood which bulges out the end of lower pipe. The upper is rasped and fits in smoothly for half an inch. The pipe is then painted with lampblack for 4 in.—the two inches are shaved tightly in each pipe. Then the solder [see Soldering] is poured on and wiped with a cloth. Some joints are badly made, the two ends being heated and stuck together with solder.

If the soil pipe is inside the house it may have an S disconnecting trap at the foot with a fresh-air inlet, but in this case the drain cannot, of course, be ventilated by the soil pipe, which is closed by the trap; and there must be then a second ventilating pipe from the drain by the side of the trap to above the roof. For this and other reasons the trap at the foot of the soil pipe is often an evil. There must be no curves in the pipe, and the top must be 30 ft. laterally, and 10 ft. vertically from windows.

An unventilated soil pipe ventilates itself when not wanted into the house. Never allow a trap or a drain to be unventilated. All wastes and sinks should have a syphon trap with a screw to prevent foul "soap" air entering the house, and to wash out the trap. Whenever the pipe is entered by others, as we have seen, an anti-syphonage pipe is needed.

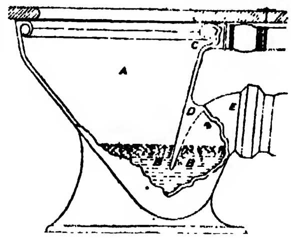
Where iron pipes are used they should be coated with Angus Smith's Tar Solution. They must have sockets and be caulked with lead, and *not* with putty or cement

Wastes may discharge into the hopper head (with a wire cover) of stack pipes. Rainwater pipes must never be used as ventilators for drains.

All wastes must, by law, now discharge into the open air on to a channel 18 in. from the gully trap. This law, however, is not to be

commended, as it causes needless smells in that 18 inches. There is also the danger of overflow from the cistern.

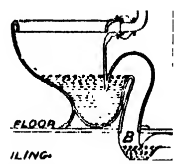
In yard traps, for surface water of the yard, the seal often dries up and lets out the gas. Unsealable traps should never be used. Sink wastes should be trapped under the sink, and go into a grease trap, and there should be an automatic flush of four gallons.



15. WASH-OUT" CLOSET
a. Basin b. Level of water forming seal c. Flushing pipe d. Flange forming trap . Drain

Yard inlets to the drain for air are often outlets from the soil pipe, if the air in it is warmer than the drain. A 4-in. flush of a large closet will draw the fresh air out of the inlet; inlets, therefore, are often dangerous, and should not be near windows. All gully traps should be self-cleansing, for they are never cleansed.

Briefly, the dangers attending domestic sanitation are these: Bad seals, dry seals, syphonage, wastes discharge with drain, unventilated drain in soil pipes, the possibility of the water seal being destroyed by syphonage, and pressure of gas and evaporation. These matters are so simple that they can be seen to by any intelligent householder without any difficulty, and are of great importance to health.

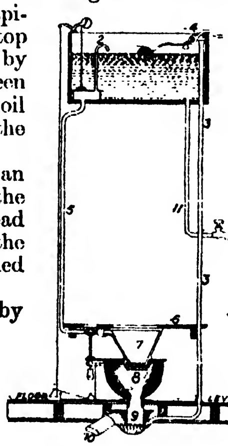


16. SYPHON CLOSET
b. Second trap

Sewer gas contains sulphuretted hydrogen, ammonia, and 4 per cent. CO, and germs. It may produce peritonitis, puerperal fever, pneumonia, sore throats, typhoid, or erysipelas. Sewer gas may be inodorous. Inmates of hospitals have been poisoned from the top of the soil pipe being ventilated by the larder, and people have been poisoned by the nearness of the soil pipe to an open cistern in the roof.

In Caius College, Cambridge, an epidemic of typhoid was traced to the splash of a closet pan into the lead safe beneath. A pipe drew up the germs into the main, and poisoned the water supply.

The drains should be tested by water pressure and by smoke test. Half an ounce of oil of peppermint, placed in the highest closet, can soon be detected below if there is leakage anywhere.



18. PAN CLOSET
1. Lever 2. Air-pipe 3. Overflow 4. Ball cock 5. Flush pipe 6. Seat 7. Closet basin 8. Container (iron) D trap (lead) 10. Soil pipe 11. House water

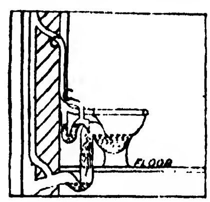
Cisterns. Cisterns should be covered, and dark. The cubic feet multiplied by six gives the contents in gallons, and, divided by five, the number of people it will supply. If they are of lead, they must not be scraped when cleaned.

Hot water supply is often dangerous. The old fashion of a tap in the boiler, or drawing off water direct from the boiler, is bad, and has nearly gone out. The modern plan of a reservoir of galvanised iron, tested to 20 lb. to square inch is very good. Where there is nothing but the boiler and hot cistern and the two pipes explosions are common, but when the intermediate reservoir is used they are unknown.

We will conclude with domestic refuse, which includes excreta, slops, kitchen waters and grease, bones and scraps, broken iron and crockery, dust, ashes, cinders, and rubbish generally.

London house refuse works out at 4 cwt. per head per annum; in the country, 7-10 cwt. Points to be noted in this connection are speedy removal of excreta, prevention of foul deposits and escape of gas, the ventilation of all pipes, and provision against sewer gas in the house.

Each person loses ½ lb. of solids and 1 quart of fluid daily. There must, therefore, be good drains, well laid and accessible, ventilated, and not under the house. Good closets, lighted, in outside wall, ventilated, with windows. All wastes must discharge in open air. There must be separate closet systems, and an abundant *constant* supply of water. No leakage and no waste-pipe in bed-rooms.



17. CENTURY CLOSET

The old insanitary brick ashpit is now done away with, and the new galvanised dustbin, with lid, has taken its place [23]. It must not contain more than one week's refuse, and should be about 15 in. by 18 in., with perforations at the bottom of each side. The capacity should not be above 2 cubic ft. No decomposing or wet matter must be thrown on it, but should be burnt.

House refuse should not be mixed with manure and spread on a field. At Hendon this practice caused an outbreak of diphtheria. Town manure is kept above the ground in places with cement bottoms and wire removable cages round. No manure heaps are allowed in town stables.

Prevention of Disease. The tables appearing on page 5056 give a list of some of the most common diseases, with the time of incubation and length of the duration of infection. The school law, showing when a child may return, is also given, and it is one that should be strictly adhered to.

We should now consider the principal preventives against disease.

1. Modify susceptibility by protective inoculation.

2. Attention to health measures against specific causes.

3. Stamp out by compulsory notification and immediate removal to special hospital.

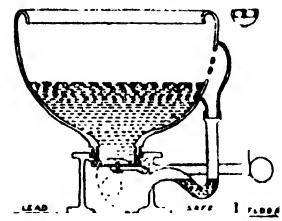
4. Isolate every case.

5. Isolate and watch each person for 14 days, and destroy all infected clothing. Quarantine is ineffectual.

6. Always notify an outbreak of disease to schools and close them in epidemics.

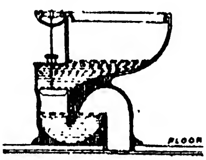
7. Revaccinate persons over 14, also when an epidemic of smallpox is about.

8. Disinfect all clothing, furniture, and rooms. All clothes and linen, etc., should be boiled before being sent to the laundry. Steam is better than heat for cleansing. Moving steam is most effectual, dry air least so.

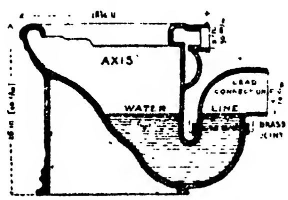


19. VALVE CLOSET

Drying alone does not kill the spores of germs, or even the bacteria in all cases. Steam is best, because of the latent heat required to raise water at 212° F. to steam requires 1,000 times more heat than to raise water from 211° F. to 212° F. This heat steam parts with when penetrating the cold clothes. Hot air has no such latent heat to give out. It should be borne in mind that $\frac{1}{500}$ perchloride of mercury kills all bacteria, and $\frac{1}{1000}$ perchloride of mercury destroys all spores.



20. PLUG CLOSET



21. AXIS CLOSET
Connection between outlet and lead

Disinfection After Disease. Hot chambers and two separate rooms should be used for disinfecting by steam, with heat not over 250° F., or it will scorch. For disinfecting rooms, 3 lb. of sulphur will do for each 1,000 cubic ft., or sulphurous acid can be set free. One per cent. of sulphurous acid in the air kills all germs, but even 6 per cent. will not kill all spores.

Never less than 1 lb. per 1,000 cubic ft. should be used for dry burning. This produces SO_2; but the active disinfectant is H_2SO_3 or $SO_2 + H_2O$ (water); therefore, before fuming the room, the walls should be well moistened with water or steam.

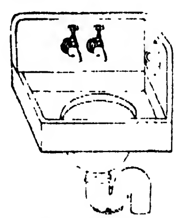
Typhoid fever requires that an equal quantity of 5 per cent. H_2SO_4 (sulphuric acid) and permanganate of potash be added to the volume of each stool. This is a real steriliser. Carbolic acid is used to kill all germs but typhoid. Lime should be added before emptying it into the drain, in order to neutralise the acid.

The only solutions that have destroyed spores in twenty-four hours are chlorine, bromine, and iodine water, chloride of mercury, permanganate of potash 5 per cent., osmic acid 1 per cent., and carbolic acid 5 per cent. Deodorisers mask the smell only, while antiseptics stop the growth of the germs.

The Lyons disinfecting steam chamber consists of superheated steam. Steam is raised to three atmospheres, or 30 lb. steam pressure. This steam is made to circulate in an outer jacket, and the heat in an inner chamber. The steam is turned on for twenty minutes, and then turned off, while the heat of the chamber dries the articles. Steam at 220° F. for eight hours, or 250° F. for one hour, or 270° F. for fifteen minutes, kills all ordinary germs.

If one cannot disinfect by steam, the articles should be soaked in carbolic (50 per cent.) for twenty-four hours. Fumigation is rarely quite efficacious and never when done at home. One cannot disinfect an inhabited room.

Notification of Disease. Increasing compulsion is being placed on the doctor to notify all infectious diseases. It is needed because people conceal their cases.



22. SLOP SINK

The diseases to be notified are: Smallpox, cholera, scarlet fever, typhoid fever, relapsing fever, continued and puerperal fever, and measles. Influenza, mumps, chicken-pox, German measles, and consumption are still exempt.

Notification can never stamp out all cases, for some are very mild, and escape recognition, although they may often, of course, be just as infectious.

Isolation. To ensure complete isolation the patient should be in an empty room at the top of the house, with a sheet saturated with carbolic acid (5 per cent.) and water before the door. The window should remain open, and the room should contain no furniture or carpet. A special nurse should be engaged and no one else should enter the room but the doctor. The nurse's hair should be covered, and a linen or cotton washing-dress worn. All utensils should be immersed in water containing a proportion of 3 per cent. of carbolic acid, and all linen soaked. Rags should be used for handkerchiefs and afterwards burnt. Carbolic soap should be used for washing, and carbolic oil, if oil is needed, should be used on the body—the best is acid carbolic, 1 drachm; eucalyptus, 3 drachms; and olive oil, 8 oz.

23. DUSTBIN
Capacity, 2 cubic ft

Disinfection consists in destroying germs, and not only in removing smells or arresting putrefaction. Condy's Fluid is an antiseptic.

Nuisances. It may not be out of place here to consider what constitutes a "nuisance." The following are those which may be abated under the Health Acts:

1. Any premises that are in such a state as to be a nuisance or injurious or dangerous to health.

2. Any pool, ditch, gutter, watercourse, cistern, water-closet, earth-closet, privy, urinal, cesspool, drain, dungpit, or ashpit so foul or in such a state as to be a nuisance or injurious or dangerous to health. This is commonly put in force for defective drains.

3. Any animal kept in such a place or manner as to be a nuisance or injurious or dangerous to health.

4. Any accumulation or deposit which is a nuisance or injurious or dangerous to health. This does not apply to accumulation in connection with certain trades, but to dustbins, manure heaps, rag and bone shops, etc.

5. Any house so overcrowded as to be injurious or dangerous to health of inmates. This is an important provision, especially when whole families in such numbers sleep in single rooms. Provisions as to overcrowding are not put in force as they should be, either for health or morality.

6. The absence from any premises of the water fittings prescribed by the Act, thus rendering the house unfit for habitation.

7. An unoccupied house without a proper and sufficient supply of water.

8. Any factory or workshop which is not a factory according to the Act, and which:

(a) Is not kept clean and free from effluvia of drains, closets or other nuisances.

(b) Is not ventilated so as to be harmless, and contains gases, vapour, or dust that are a nuisance or dangerous to health being carried off.

(c) Is so overcrowded while work is carried on as to be injurious or dangerous to health.

(The offensive trades are dealt with separately. This aims at home workshops and sweating dens.)

9. Any tent, van or shed which is a nuisance, or so overcrowded as to be injurious or dangerous to health.

10. Any fireplace or furnace which does not as far as possible consume its own smoke.

Respecting nuisances the sanitary authority can make any one of four orders. They can:

(1) Abate the nuisance—an abatement order.

(2) Forbid its recurrence—a prohibition order.

(3) Combine the two first—a combination order.

(4) Close the premises—a closing order.

Disobedience to a nuisance order may be punished by a fine of 20s. a day and upwards.

If an owner or occupier fails to abate a nuisance the sanitary authority has power to take all steps and execute all work necessary and charge the expense to the owner.

With regard to tenanted houses, the Act requires that any sanitary authority shall make and enforce such by-laws as are necessary for:

(1) Fixing the number of persons who may occupy any house, or part of a house, let in lodgings, and regulate the separation of the sexes as needed.

TABLE OF INFECTIOUS DISEASES

Disease.	Incubation.	Duration of Infection.
Chicken-pox	10 to 14 days	3 weeks
Cholera	1 ,, 5 ,,	3 ,,
Diphtheria	1 ,, 8 ,,	6 ,,
Diarrhœa	1 ,, 4 ,,	2 ,,
Enteric, or typhoid ..	8 ,, 14 ,,	6 ,,
Erysipelas	1 ,, 5 ,,	1 ,,
Influenza	1 ,, 21 ,,	3 ,,
Measles	8 ,, 20 ,,	4 ,,
German measles	6 ,, 12 ,,	3 ,,
Mumps	14 ,, 22 ,,	3 ,,
Scarlet fever	1 ,, 6 ,,	6 to 8 ,,
Smallpox	— 12 ,,	6 ,,
Phthisis	not known	—
Typhus	6 ,, 14 ,,	4 ,,
Whooping-cough	4 ,, 14 ,,	8 ,,

SCHOOL LAW AFFECTING DISEASE

Disease.	Incubation.	When patient may return to school after attack.
Smallpox ..	18 days	When scabs are gone
Chicken-pox ..	18 ,,	When scabs are gone
Scarlet fever ..	14 ,,	6 to 8 weeks, and all peeling over
Diphtheria ..	12 ,,	3 weeks, and no sore throat
Measles ..	16 ,,	3 weeks, and no cough
Whooping-cough	21 ,,	6 weeks, and no cough
German measles	16 ,,	2 weeks, and no cough
Mumps ..	24 ,,	4 weeks, and no cough

(2) Registering such houses so let and occupied.

(3) Inspecting such houses.

(4) Enforcing drainage, cleanliness, and ventilation of such houses.

(5) Cleansing and whitewashing at stated times.

(6) Precaution in case of infectious disease.

Cases of infectious diseases must be notified, removed and the house, etc., disinfected. On notice being given all articles must be disinfected or destroyed, or the sanitary authority can enter at any time between 6 a.m. and 9 p.m. for this purpose.

Trade Nuisances. Trades that are offensive but not necessarily unhealthy are bone, blood, soap and fat boiling.

Trades that are unhealthy but not offensive are lime, cement and charcoal burning. None of these must be established near London.

The manufacture of fat, tallow, candle, soap, blood, bone, phosphate; or the carrying on of tripe boiling, curing, tanning, glue works, manure works, sewerage and scavenging may be classed under offensive and unwholesome smells.

Poison works by contact, absorption, ingestion, inhalation—as arsenic, mercury, lead and antimony work, used as colours in wallpapers, bronzing, gilding, artificial flowers, matches, hat and enamel work.

Nuisances from offensive trades should be prevented by providing increased cubic space, perfect ventilation, screens, splashboards, fans to carry off dust, machines for doing hard work, non-poisonous ingredients used; by insisting on no meals being taken in workshops, lavatories, disinfection before entry, mechanical stokers for furnaces, respirators in poisonous trades.

[Illustrations 4–20 and 23 are reproduced from "Diagrammettes," by W. H. Knight; 21 and 22 by permission of Messrs. Twyford, Ltd.]

Continued

continued from page 4887

BRIDLES AND OTHER SADDLERY

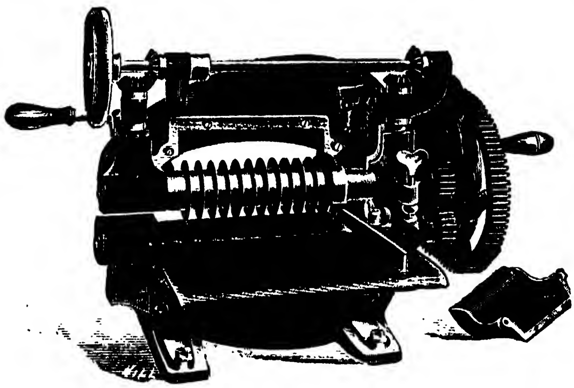
The Manufacture of Bridles, Winkers, Cheeks, Nosebands, Chin-straps, and Throat-lashes

By W. S. MURPHY

Bridles. The stuff has all been cut and lies ready to hand for the bridles. As the more elaborate and inclusive, the cart bridle is the most interesting and important to learn. Machine manufacturers have introduced novel modes of procedure; but the hand method has always been to make the parts first, and then to build them together.

Winkers. Race the sides with three deep grooves, edge with the edge tool, and blacken the edges. Soak in water a short time, bend inwards to a half circle, and nail the winkers down on a board to dry in that shape. When dry, heat a bevelling iron and polish the raced grooves.

The winkers have buckles and cross-belt in front, but the body of the winkers affords no hold for buckles. We have therefore to make chapes or loops of leather. Cut and sew on the chapes and put in the buckles.



9. STRAP-CUTTING MACHINE

Cheeks. Turn over the ends of the cheek-straps and meet them in the centre, flattening down the bends with the hammer. Cut a hole for the buckle at one end, and another in the centre of the strap, slitting it out to both sides and skiving down the edges of the slit. Fine the outer side of the cheeks with the edge tool, race double lines on the upper half, blacken the edges and the lines, and polish with a soft rag. With the pricker-wheel mark the lines for stitching, put the buckle in place, and the bit ring at the other end, then sew the ends of the cheek together. Both cheek-straps are made alike, with the exception that the faces are reversed.

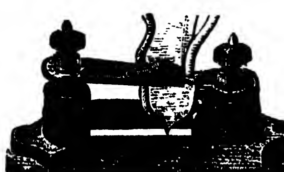
Noseband. Double back the ends of the noseband, making it about 1 ft. 4 in. in size; shave the turned-in ends, and punch a hole in the centre of the band at each side, slitting out from both holes. Edge the sides of the noseband where it is not double, race two lines along it, and deepen with the heated bevelling iron. Mark the lines for stitching on the doubled sides.

Forehead Band. The forehead band itself is very simple; but it joins on to the ear piece, which needs some managing. Edge, crease, blacken, and polish, and deepen the grooves with the beveller. Double the ear piece and flatten down and shave the undermost end. Crease and rub the top side; mark off from the bend as much space as will allow of a broad belt to slip easily through; prick for stitching the rest of the ear piece; stitch across and along. Make the other ear piece the same; sew them on each end of the forehead band, and at the joints cut a small V nick for the tongue of the buckle.

Corner Piece and Chin-strap. Corner pieces are meant to ease the joint between the noseband and the cheek; they are cut to shape and skived to pass in between the bend ends of the noseband, on one side, and the cheeks on the other. Small straps are cut with a machine as shown in 9. Cut the short side of the chin-strap in a slant from the breadth of 2 in. to ¾ in. at the end; thin the long part of the strap down to ¾ in. broad all but 2 in. of its length; turn back, and make a hole for the buckle in the narrow end; crease, blacken, and rub up both parts, and place the buckle.

Head-strap. Narrow the ends; crease, blacken, and finish.

Throat-lash. This is a typical strap, and is treated exactly as has been formerly described. Turn down at the end, make a hole for the tongue of the buckle, narrow the point of the strap; crease, black and finish; sew in buckle and loop.

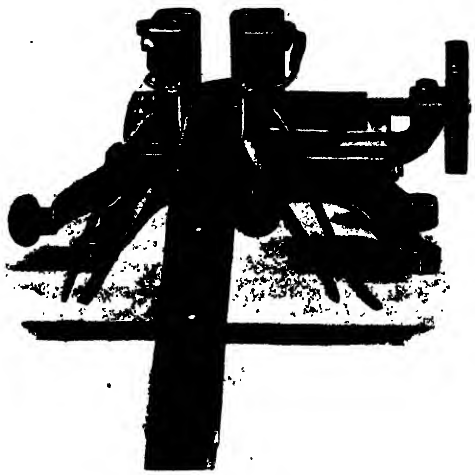


10. BEVELLING OR SKIVING MACHINE

Stitching the Bridle. The cheeks form the backbone, so to say, of the bridle. Bring the forehead band between the cheeks and fix them together with nails. On the lower ends of the cheeks we have a ring, and into this the noseband is linked. Strengthen the link by slipping the corner pieces into the fold of the noseband and the chape of the cheek. Adjust the winkers close to the forehead band, and bring up the cheeks level with a piece of leather the same thickness as the winkers, the breadth of the cheeks. Set the chin-straps, the one with the buckle going on the left side of the

bridle, viewing it from the front of the horse. Stitch the outside lines of both cheeks first; tack in the noseband on each side and continue the sewing up the inner side of the cheeks. Stitch the inner side of the noseband; level the edges all round, scrape, black, and rub with tallow or smoothing-bone. Fix in winker straps, headband, and throat-lash, and finish off in the manner already described.

Reins. We have here two reins, one long and one short. Let us begin with the short rein, and turn it over at one end for the buckle chape, at the other to go over the ring of the bit. Put four rows of stitching on at the ring end, and sew firmly the buckle. Stitch the long rein into the other ring, and adjust it.

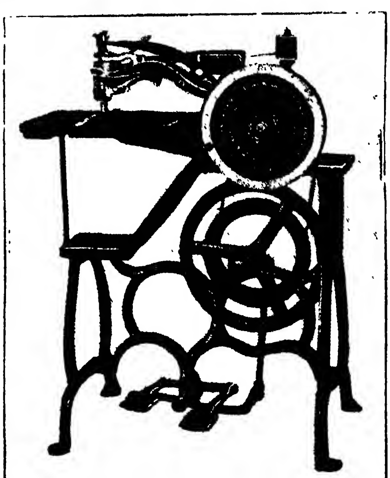


11. TRIMMING MACHINE

Several small details, such as trimming [11], bevelling and skiving [10], come up in actual working which can hardly be set down within reasonable compass; but they suggest themselves as the work grows under your hand.

Van Bridles. The bridles used in van work are different in form and kind of leather from carthorse bridles.

Winkers. The main body of the winker is the plate, which, of course, we get ready-made. Cut out the leather ¼ in. larger than the plate front and side, and ⅜ in. larger at the back. Race a double line all round the edges; prick the lines for stitching, and stitch the inner line with a double thread of black linen. Cut the lining to size, put the top on it with a little stuffing, and sew round three sides, leaving the back open. Fig. 12 shows a machine used for this purpose. Soak the leather in water, and then coat the inside of what is practically a bag with a thick coating of paste. Thrust in the plate into each winker, bringing the iron close up to the front stitching; rub well down on both sides to stick all close together; put a soft pad under the lining of the board, and fix down the winkers to dry.



12. SADDLERS' AND HARNESS-MAKERS SEWING MACHINE

Cheeks. Take the strip already cut; measure 8 in. from the end and mark for a billet; from that mark measure 8 in. and make a band. Punch a buckle hole at each end: edge, black, and crease along the billet part; groove on the under side half the thickness of the leather. Set the buckles in place and fix the winkers on the cheeks, the bottom of the winker coming level with the end turned up from the cheek-strap. Hold the edges down with tacks.

Special features of this class of bridle are the loops, which are large and important. Having cut the loops, 7 in. by 1¾ in., from good stiff leather, form them square on the loop stick, then set the side of one half-way under the cheek, stitch it in the groove, and bring over the other side of the loop in the same way. The other cheek is treated similarly. Next, the loop is ornamented in the usual style.

The other specialities of the van bridle may be briefly given. The noseband is lined on the inner side. Forehead band, headband, and throat-lash join together in a rosette at the top of the cheek-straps, the ear and corner pieces being absent.

Riding Bridles. Curiously enough, the riding bridle is at once the simplest and finest of all its kind; cut out of the very best light leather, and sewn with silk or the highest grades of lint.

The cheeks of a riding bridle have buckles at each end, one held by a chape turned over and one by a billet sewn on to the back. Set the buckles in place, leaving space for a loop in front; stitch from the back in order that the best face of the stitching may lie to the horse.

As the head-strap has to join the throat-lash and the cheeks, it must be kept broad; slit it 5 in. on each side. Take the front band and bend over each end so as to enclose the head-strap comfortably and leave room for stitching. Turn down the throat-lash for the buckles, and fit into place. Now stitch down all the ends with a double row of stitching. The stitching of the bridle requires to be neatly and soundly done, not only for the appearance, but also for the wearing quality of the bridle.

The Pelham bridle has a noseband, and the Wymouth has a double head; but these have already been shown.

Continued

THE BAGPIPES

Distinguishing Features of the Scottish and Irish Bagpipes. The Parts. Fingering. Grace Notes and Other Effects. Exercises

Continued from page 4901

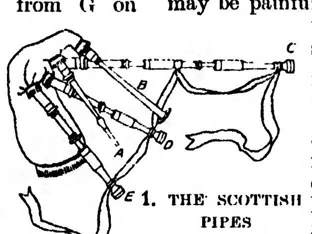
By ALGERNON ROSE

SCOTTISH BAGPIPES

To-day, in Scotland and Ireland, we possess the most highly developed examples of the two great varieties of the bagpipe. First, we have those blown by the mouth, and secondly, those inflated by bellows worked under the arm.

The air which supplies the Scots' pipes is contained in a receptacle of leather held under the left arm [1]. In this bag are five holes, which furnish sockets for as many tubes. First, we have the blow-pipe, which supplies as much breath as will keep the skin well filled; secondly, there is the chanter, or melody pipe, which plays the tune to which the troops march. Thirdly, fourthly, and fifthly, we have the drone pipes, or stocks, which give accompanying sounds to the air. At the base of each drone-stock is a single beating reed. The chanter, however, at its apex, is furnished with a double reed somewhat akin to that of the hautboy.

The Chanter. The beginner, before attempting to play on the entire instrument, must first take up what is known as a "practising chanter." Such a pipe costs from 5s. to £1, according to the make and finish. The tube is pierced by seven holes—four large and three small. In the mouthpiece joint is situated the double reed, over which is screwed a wooden tube or cover, tapering almost to a point. Place this end in the mouth, and blow. The breath will cause the reed within to vibrate and produce the tone of the open note. The melody scale of the bagpipe is confined to seven sounds. Formerly, these had separate Celtic names, by which alone they were known. To-day, although they are not quite in tune with our scale, they are represented by the notes which run from G on the second line, treble clef, to F, on the fifth line. This compass may appear exceedingly simple: yet, although there are no sharps or flats, the wonderful way in which melodies are embroidered by a wealth of grace notes dexterously interpolated necessitates long and persevering study before the instrument can be mastered.



1. THE SCOTTISH PIPES
a. Blowpipe b. Chanter c, d, e. Drones
(Mahillon & Co.)

Hand Position. Beginning with the practising chanter, detached from the bag with drones, place the fingers of the left hand uppermost so as to stop the three top holes. The first, second, third, and fourth fingers of the right hand cover the lower holes. The latter fingers must be placed well across the chanter, so that the smallest easily stops the lowest ventage. Whereas in flute, clarionet, and hautboy playing the tips of the fingers and a very light surface touch is used, in Scottish bagpipe playing this is not the case. Do not stop the holes with the finger-tips. Cover them by the fleshy part of the finger between the middle joints. Keep the thumb exactly under the right second finger to give proper leverage for the digits above. Place the left thumb on the hole at the back of the chanter, the left first, second, and third fingers stopping the apertures above. In playing, the fingers must not be curved, but must fall rigidly upon the holes without being bent.

To make this action more emphasised, raise each finger high above the chanter so that, as it descends, it may give a report without the assistance of the breath. Later on, when the student gets facility in the playing of grace notes, and the fingers have to move rapidly, the endeavour should be to make them fall on the pipe with the strength of small steel bars, so that when each finger is lifted it may be taken away cleanly, in order that every note may be distinctly articulated. Therefore, in practice, exaggerate the finger movements at first. Lift each digit stiffly as high as possible, and bring it down with force. Movements should all be from the knuckle joint. We give a representation of the chanter, showing the reed, and another with the reed covered for practising purposes [2]. To the latter is appended a representation of the way in which every note in the scale is obtained in the fingering. Closed notes are marked by an opaque disc, and open notes by a circle. The top G and A, it will be observed, have alternate methods of fingering.

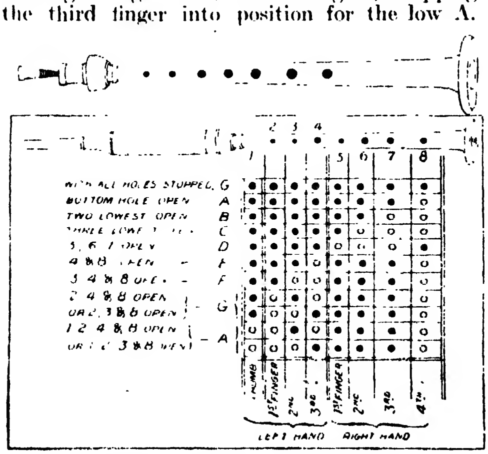
Fingering. This method of rigid playing may be painful at first, especially with the right thumb held tightly under the second finger. But it must be kept there, well down, to give the lower fingers their requisite power.

Now put down all the fingers and sound the low G, counting four slowly. The little finger must cover the bottom hole cleanly. Now lift it, and blow the A, counting four beats slowly. Lift the third finger and blow the B, keeping correct time. Lift the second finger and blow the C in the same manner. To get the D, lift the first right finger and put down the little finger on the bottom hole. For the E above, raise the third left finger, and, simultaneously, the little right finger, whilst the first, second, and third right fingers are brought down. If this is not done cleanly, the note A will be heard to sound in between, and the effect will be spoilt. Be

very particular, therefore, to make the change correctly, and repeat the notes D and E until the result is satisfactory. To get F after the E is easy, as the same fingering is used, except that the second left finger is raised. But, to get the G after the F needs almost as much care as changing from D to E. In putting back the second finger of the left hand and raising the first, they should just pass each other, so that no intermediate sound is heard. For the A above the G, remove the left thumb. Another way of producing the same note is to leave open the thumb-hole and first and second vents as well as the bottom hole, stopping the third, fourth, fifth, and sixth holes respectively with the third left finger and first, second, and third right fingers. With this fingering, the top G can also be sounded by closing the thumb-hole.

The Grace Note. A grace note means an embellishment, or ornament, to a tune which is being played. Although it is not essential to the melody, it invests Scottish bagpipe playing with a distinctive and peculiar charm. Great players please themselves as to the way they introduce such embellishments, and some pipers, between the last up-beat of one bar and the first down-beat of the next, will execute distinctly as many as eleven grace notes. These are called "warblers," and are said to resemble the warbling of birds. It is important, therefore, for the beginner to acquire, by diligent practice, the ability to execute shakes, double-cuts, and other graces, before attempting to play tunes.

Beginning the scale again, introduce, before each long sound, the first grace note, or top G. This is effected by raising, and putting down sharply, the first left finger on the top hole, leaving all the other holes meanwhile closed. This will give, first, the G grace note, and then the full low G note. The grace note should always be of the shortest possible duration. After the low G has been sounded, take off the right little finger and the right third finger in succession, so as to blow the A and B above steadily. Next, let the top G sound precede the second note in the scale, A, by raising the first right finger, and, while doing so, dropping the third finger into position for the low A.



2. THE CHANTER (Metzler & Co.)

Bringing the first finger down smartly will sound the G as before, the low A immediately following it. Then raise in succession the second and third fingers to finish the triplet consisting of A, B and C. Again, raise the grace note, dropping at the same time the second right finger, to produce B. Stopping the top hole with the first finger smartly will give the grace note, and lifting the second and first right fingers will sound the C and D above, provided the little finger is put down for the latter note.

The next triplet requires special attention. Raise the grace note, putting back the first right finger for C, and lifting the little finger. Then bring down the first left finger for the grace note, and sound the C, raising the first right finger and putting down the right little finger for D, and then dropping the first, second and third right fingers and lifting the little finger as well as the third left finger to give E. This must be practised until the sounds come smoothly. Again, raise the first left finger for the grace note, bringing the right fingers into position for D. Then put down the first finger smartly to sound the top G; drop the first, second and third left fingers and raise the little finger, together with the third right finger, for E, raising next the second left finger for F. Take care, in the finger changes, that they are made with precision, so that no A may sound in between. Couple the top G with the E by raising the grace note and dropping the second left finger. Then put down the grace note smartly, sustaining the E, following this by the F, by raising the second left finger, and the G, by taking off the first left finger and putting down the second.

We have now arrived at the grace note itself. To couple that with the F below is scarcely possible, so the A grace note takes its place. To get this, raise the left thumb and close the holes smartly. At the same time, depress the first left finger and the first, second, and third right fingers for F. Repeat the sound G. Then raise the thumb for A. If these instructions are followed this exercise will be found less difficult to execute than appears at first sight. [Ex. 1.]

The "High A Shake." Having learned to interpolate one grace note before each triplet without disturbing the steadiness of the latter, proceed to master the introduction of two grace notes by coupling, with the G, the high A. This is called the "high A shake." The G finger, as we have seen, is the first left finger. In like manner, the A is given by the left thumb passing with a smart upward movement over the hole in the back of the chanter. Great care must be taken before sounding high A following a low note not to put down the right hand before the left is raised. Now depress all fingers for low G and then prepare for a long top A by raising the first and second left fingers, the little right finger, and uncovering the thumb-hole. Before sounding this, interpolate the A and G grace notes by smartly closing the thumb-hole and the top hole rapidly in succession, and immediately opening them again. In the same way sound the low A by stopping all the holes except the bottom one and preparing for the

top A, as before, preceding it by the two grace notes. Then sound the B, the C, and D, in like manner, always preparing for the long A which follows, making all movements emphatically and cleanly; otherwise the effect will be spoilt by a wrong sound coming in between. [Ex. 2.]

Having doubled the high A with the G in between, the student must now double the G, with the F as the passing note. The way to join the grace note F to the grace note G is learnt by practising the "high G shake." It will be seen by the diagram that to produce the F and G at the top of the treble clef, the first, second, and third right fingers are down for both notes, as well as the left thumb, but that the first left finger is down for F and the second left finger for G, all other holes being left open. Yet the G here is not fingered according to the scale, as the whole of the left hand, except the thumb, is raised. For the G shake, therefore, raise the first, second, and third left fingers as well as the little finger, striking the top hole of the chanter smartly with the first. Between the two G strokes the connecting F will sound. Practise in this manner the high G shake from the low G to the F above. [Ex. 3.]

Doubling the Notes. Having doubled the G with the F, sounding the top G twice, endeavour now to sound the top F twice, interpolating before it the three grace notes, G, F, G, by raising the first, second, and third left fingers, always keeping the right little finger up. Put down the first left finger smartly, raise it, and put it down again. This repeated stroke by the first left finger gives the G, F, G shake and the sustained F to sound the long note. The beginner must work day by day to get the F shake cleanly, linking it with the other notes of the scale from G to E, and then with the top A. [Ex. 4.]

Having doubled the A, G, and F, now practise to double the E. The "E shake" consists of the grace notes G, E, and F linked together. This is done by raising smartly the first and third left fingers, keeping up the right little finger. Bring the first left finger down. Then raise the second left finger and put it down also. See that the first is down before the second is raised. Before beginning the shake, always sound the first note of the group. Now blow the low G with all the fingers down. Remove the left fingers. With the thumb strike the octave G above. Keeping it down, slip the first finger over the top hole, raising the second finger and bringing it down smartly for E. Take off the E finger immediately, and strike the top hole for the F, repeating the E. The shake needs, of course, careful practice before it can be done with facility. [Ex. 5.]

The D shake consists of linking together quickly the low G, D, and C before the second D is sounded. Close all holes on the chanter, then raise smartly the first, second, and third fingers to get the D above; strike the first right finger for the C, and then sustain the D, keeping the little finger down. [Ex. 6.]

The Grip. What is known as the "grip" or "round movement" is the alternation of low and high notes, preceded by appoggiaturas, the first sustained note being dotted. Now the student who is familiar with musical theory may be reminded that a dot or point placed after a note increases its duration one-half. The next note

Ex. 1.

Ex. 2.

Ex. 3.

Ex. 4.

Ex. 5.

Ex. 6.

Ex. 7.

Ex. 8.

being diminished in proportion, the effect is generally staccato, or, at least, semi-detached in a fairly quick passage. In Highland music, the interpolation of grace notes gives a swing or jumpiness to a melody difficult to describe; and in reel playing, unless the fingers have been trained to put the grace notes in neatly, the entire idea of the "snap" is lost. Now endeavour to get a long A, preceding it by top G, and a long D and E, preceding them by two bottom G's. This gives the so-called "round movement." Prepare the fingers for A, and, immediately before sounding it, strike with the first left finger for top G. Prepare for D. Close all holes of the chanter for low G, and strike the D finger smartly, lifting E with the little finger. Here, although D is written as a plain note, it is played as a grace note. [Ex. 9.]

The Double Cut. What is known as "the double cut" has often a startling effect if it is executed quickly and smartly. It frequently occurs in the quickest of all finger movements, but must be practised by the student in slow time at first before the knack can be acquired, especially without the assistance of a master whose playing can be imitated. All the best players have practised industriously on the chanter until they have drilled themselves sufficiently to execute almost any combination of grace notes automatically. We give here an example of the double cut. [Ex. 7.] Tried on the pianoforte, this illustration does not convey the proper intonation of the chanter, the scale of the latter instrument not being in equal temperament. In other words, the intervals between B and D, and E and G are natural on the bagpipe, and the same as the old Arabic and Persian scales; whereas, on the piano, to which our ears are accustomed, they have been artificially tempered. So, when musicians say that the bagpipes are out of tune, it is their ears which are at fault.

Attitude. It is now time to consider the instrument as a whole. Attached to the bag, five tubes will be observed. These are, first, the blow-pipe; secondly, the chanter or melody pipe; thirdly, fourthly, and fifthly, the long and the two shorter drones. Place the bag under the left arm. Throw the long drone over the left shoulder, and let the two shorter ones, connected by a ribbon, hang down fan-fashion. Place the blow-pipe in the mouth, and blow out the bag till it is full, keeping the left arm pressed firmly on it, so as to have the chanter and drones going when pausing to take breath. So feed and press the bag that an equal current of air is maintained when a piece is played. Instead of the breath acting immediately on the chanter, as in the preceding exercises, the melody pipe, held by both hands, is now fingered lower down, as it is fed with wind from the bag.

In beginning to "wind" the bag, the student may hold up the drones on the left shoulder with the right hand. With his left hand, he must stop the thumb-hole and the first and second vents. The bag can then be blown out full, and placed under the left arm. Two drones ought to be stopped, and only the smaller used at first, until the beginner, by alternately blowing and pressing, is able to keep the wind steady.

Tuning. The player tunes his instrument to A by closing all holes in the chanter excepting the lowest. Check the low A with the octave A above. If the two sounds are correct, the chanter reed is all right. If it sounds flat with the long drone it must be made to agree. The reed will be heard vibrating very quickly if it is wrong. Shift the joint of the drone by pulling the tuning-string back or forward till the pulsations get slower and become steady. Different players tune the drone-stocks in various ways. Pipe-Major Glen recommends, in some cases, all the drones being tuned to A. Henderson prefers the big drone being tuned to E. Other players set the drones to G, D, G, and G, D, A, giving the tonic and dominant drone bass. Always let down the reed if too flat, or raise it if too sharp.

Particular care should be taken in adjusting the reed of the chanter, because the slightest alteration may make considerable difference to the pitch. Having closed the two longer drones, the student should now practise the exercises he has learnt, with the smallest drone. When these are performed satisfactorily, the whole three drones can be set going. The point is, when playing, always to keep the bag tight, or fully distended. Any good piper will affirm that the body of the instrument is remarkably sensitive; when in order, it will respond to very gentle pressure. It stands to reason, then, that if the skin is allowed to get hard and dry, its elasticity, or sensitiveness, will be gone. It will neither fill nor empty itself readily, nor answer to the wishes of the player, so that notes will

be missed and the performance unsatisfactory. If, therefore, the pipes have not been used for a while it is the custom in some Highland regiments, the day before a march out, to prepare the instrument in this manner: Take off the cover of the bag, and cork the drone-stocks tightly. Mix three tablespoonfuls of treacle with two tablespoonfuls of water. Pour this into the bag, and hang up the instrument so that the liquid runs out through the chanter stock. If this is done overnight, by the morning the contents will have percolated through the tube. The performer will feel, when his arm presses the bag, that after this treatment the response of the instrument is delightful.

Progressive Practice. Considering the work there is in the manufacture of a set of Highland, or military bagpipes, the cost, compared with that of many other musical instruments, is small. A full set can be obtained from £5, and sometimes less; and what are known as half-size, or reel pipes, suitable for a drawing-room, can be obtained from about £3. The student, having practised the preliminary exercises on the full instrument, should now proceed to learn simple tunes. Such music can be procured from the Highland Pipe Society, 154, Oxford Street, London. Pains should always be taken to play at first slowly and correctly. If a difficulty is encountered which needs much repetition, it is better to learn it first on a practising chanter, and concentrate the mind on the fingering. Steadiness in position should always be maintained, no matter how staccato the music which is performed may be. Valuable assistance in preserving correct time and a slow rhythm in practising can be obtained by the use of a metronome. Playing in quick time will come easily when correctness in slow practice has been mastered. In conclusion, we give the first eight bars of the March of the Seaforth Highlanders. [Ex. 8.]

Ex. 9.

IRISH PIPES

Here we have a much more elaborate and complicated instrument than the pipes used in Highland regiments. There are no written instructions for playing the Irish pipes to be found, either in Gaelic or English. In this respect, therefore, we are breaking entirely fresh ground.

Union Pipes. The instrument was used originally for military purposes, each force being led by a musician with bagpipes more than twice the present size, as the longest drone measured upwards of six feet. The other drone, instead of being spread out fan-fashion, like the Scots pipes, was carried over the left shoulder, close together, like a bundle of sticks, and the bag hung down in front instead of being placed under the left arm. Both of these features are preserved in the Irish pipes of to-day. The Union Pipes contrast with those of Scotland chiefly in three respects. First, instead of the tone being strident and warlike, it is mellow and fluty. Secondly, instead of being blown by the mouth, the bag is inflated by small bellows. Thirdly, the compass is not only more extensive, containing 25 semitones instead of 9 notes, but the drones are furnished with keys capable of giving an accompaniment of varying harmonies.

Position. Place round the neck, over the right shoulder, the broad strap which supports the instrument. Tuck the bellows under the right arm so that the elbow may work them easily. When the performer stands to play, these bellows are kept up conveniently by placing a walking-stick underneath them. The bag, then, is suspended in front, well up, and inclined to the right, so that it can be easily supplied with wind. Below the bag hangs the chanter. Hold the lower joint of this with the fingers of the right hand. The Irish idiom "More power to your elbow" refers to the playing of the pipes, because both elbows have important duties. Whilst the right elbow must pump the bellows steadily, the left manipulates the top keys of the cronan, or drones.

With so much work to do, the most convenient position for the performer is, obviously, to be seated. In that case, the bag is nursed in the lap, and the butt, or socket, of the cronan comes well under the chanter, resting on the left thigh. The chanter itself is inclined to the left, and the drones, which are all close together, project in an oblique direction over the left shoulder. The left hand is placed on the socket of the drones in such a way that the forearm and elbow can press down the upper keys. But the lower keys are negotiated by the right wrist, or the right fingers when the latter are not needed for the chanter. So the right fingers either stop the bottom holes and keys of the chanter or the bottom keys of the cronan, the wrist otherwise negotiating the latter, while the right forearm presses the bag when needed, and the elbow pumps the bellows. The left fingers manipulate the top holes of the chanter, the left forearm, as well as the elbow, being used for the levers, or keys, of the cronan. The regulators, or cronans, are either two, three, or even four in number. They fit into a large circular socket or tube, much in the manner of the Chinese "Tcheng."

The Tone. Those who have heard this instrument played in Sir Villiers Stanford's opera, "Shamus O'Brien," will know that the tone of the Irish pipes is entirely unlike the Scottish. The upper notes have been compared to the flute and the lower to the chalumeau of the clarionet. The smallest Recorder was pierced in olden times, like the Irish chanter, with eight holes, seven in front and one at the back for the left thumb, the thumb-hole being the most important feature. In tuning, the reeds of the Irish pipes, should the vibrations be too strong, must be subdued by the application of a little melted wax.

The Chanter. The chanter is cylindrical, and of greater length than in the Highland instrument. An important point is that it is tuned to the modern scale in equal temperament. Instead of the lowest note being G

(below second ledger line, treble clef) to the octave above, it extends from D below staff to D above second ledger line, or two octaves, with all the intervening semitones. These are made practicable by the keys, the usual chanter having eight of the latter. So the compass is that of the ordinary eight-keyed D flute, the fingering of which is given with that instrument. When notes are required in the higher register, the right forearm exerts extra pressure on the bag. The knack of doing this can only be acquired by the student stopping the drones and practising the chromatic scale very slowly, both ascending and descending, until the tone is given correctly. In any case, mastery over the chanter must be obtained in playing melodies correctly before a harmonised accompaniment is attempted with the cronan.

The Cronan. Even as the word "chanter" implies "singing" the tune, so does "cronan" mean "crooning," or droning a chorus to the air. Generally speaking, the cronan are two tubes placed laterally together, so pierced as to produce thirds at the upper and fifths by depressing the lower levers. These levers are worked, as far as possible, with the wrist of the right hand. The longest tube gives the drone bass. This can be shut off at will by means of a valve, so as not to interfere with an accompanying harmony for which it is unsuited [Ex. 10].

Ex. 10.

In a typical instrument we have handled with three regulators, or drones, the longest gives the four-foot F, written on third ledger line below treble clef, a semitone below the lowest note on the violin, which shares the musical honours in rustic Ireland with the bagpipes, so that both instruments can be played together; and, moreover, before the piper starts, he invariably tunes the reeds of the cronan to the same note as the fiddler—namely A. The second regulator, being not quite 2 feet, produces, as its lowest note, C♯ below treble staff; and the shortest regulator, about a foot and a half long, gives, as its lowest note, E, first line, treble clef.

If the instrument which the student possesses has only two regulators, he must ascertain their notes for himself; but the reeds should always be tuned to A. It may be helpful if the cronan, to which we have referred, are described. The longest has four brass levers, or keys, closing as many holes. First, inflate the bag, and with the left elbow press down the lever furthest from the stock, or socket. This in an instrument with three cronan will give G below second ledger line, treble clef. Get the elbow over the second lever, so that both upper keys are depressed. The result will be A. With the right hand depress the third lever. This will give B. Finally, with the right wrist, press down the fourth lever. The sound will be C♯. Now pull the valve to shut off the sound in the long tube, and open the valve of the second, or medium, regulator. Working it in the same way, when the top lever is down D below treble staff will sound; when the next lever is down the result will be F♯. When the third is depressed the note given will be G. With all four down the result is A.

In the same manner, try the shortest drone. This usually has five keys, and therefore gives six sounds, the deepest being that when all the levers are down—namely E, first line, treble clef. Putting down the top lever with the elbow, the result is F♯, first space, treble clef. Pressing down the next, together with the first, G is obtained. Getting down the three together, the result is A. Pressing down four, the sound is B. With the whole five down, the result is C♯, third space, treble clef. Thus it will be seen that with a little practice it is possible to get all parallel keys, from the top downwards, depressed simultaneously. The two lowest notes of the two longest drones are in fifths. Then we have three consecutive sixths, whilst the two shorter tubes give two consecutive thirds, a second, and three consecutive thirds.

If the elbow places down the top lever of the longest and medium regulators and the two top levers on the shortest regulator, G, D, and octave G will sound simultaneously, giving a rough tonic and dominant drone bass to the bottom D of the chanter. Put down the two upper levers on the longest and medium regulators and three on the shortest. The effect will be A, F♯, and octave A, or the common chord of D. Put down the three upper levers on the long tubes and four on the shortest. This will give B, G, and B, or the first inversion of the common chord of G. If all the levers on the three cronan are down, the result will be C♯, A, and C♯ above, or the first inversion likewise of the common chord of A.

Bagpipes concluded

MORSE SOUNDER AND RELAY

The Simplest and Most Popular System of Telegraphy. Wheatstone's ABC System

Continued from page 4904

By D. H. KENNEDY

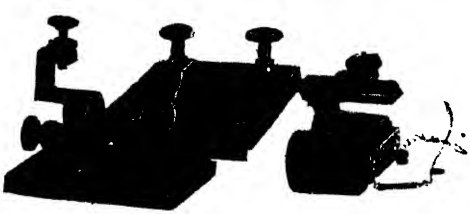
THE single-current key was described on page 4383.

The student who has read the description of the sounder, given on page 4383, should also refer to Professor Thompson's explanation of the principle of the electromagnet, given on page 562. It now remains only to add that the two coils are wound to a total resistance of 20 ohms. The two inner ends are connected together, and the two outer ends carried to the terminals. The resistance of the electromagnet is therefore 20 ohms. The current required to work a sounder is 90 milliamperes.

In the wooden base of the sounder there is inserted a 500-ohm resistance coil [see page 790]. Its ends are brought to the brass terminals, so that it is in parallel with the coils of the electromagnet, and their joint resistance is 19·2 ohms. Fig, 26 shows a complete sounder, and 27 its separated parts.

There is a more recent pattern of sounder in which the resistance of the electromagnet coil is 21 ohms, and the shunt 440 ohms, making a joint resistance of 20 ohms. The resistance coil is introduced to provide a path for the high voltage induced secondary current which is generated at the instant when the circuit of the electromagnet is opened after being energised. In the absence of such a path, injury to the relay contact points results, owing to excessive sparking.

The function of the galvanometer was explained on page 4606. It is now necessary only to add that except for its external appearance the single-current galvanometer is practically the same instrument as the receiving portion of the single needle. It is usual in joining up these instruments to form a direct working sounder set, to connect a five-ohm resistance coil in parallel with the galvanometer. This is done because the current required to work the galvanometer is only about one-seventh of that necessary for the sounder, and the introduction of this shunt reduces the total resistance of the circuit, and thus tends to reduce the number of cells required for battery power. Fig. 28 is a diagram of the connections.

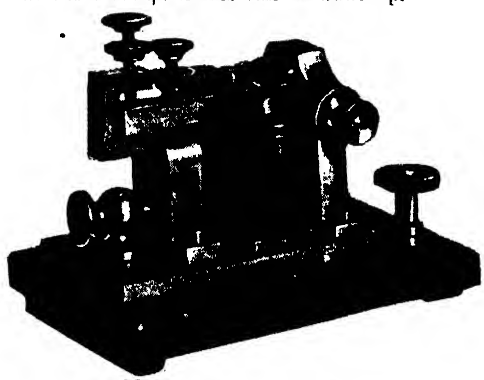


27. SOUNDER PARTS

The student must take pains to become thoroughly familiar with it because from it we shall develop more complex cases. He should sketch it out as shown in 29.

This will enable him to see clearly how the key see-saws between the sounder and battery connecting either one or other in the circuit. He should note how the line is arranged at each station. Then he should follow the path of a received current, and number the terminals 1 to 6, as shown.

If these numbers and terminals are carefully memorised they form a mnemonic base on which the more complex sets can be built up.

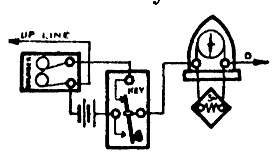


26. SOUNDER—COMPLETE

The Relay. Direct sounder working is used only on suburban circuits. As soon as the distance becomes considerable it is necessary to use a relay. The difficulty in working on long lines is not due merely to the increased resistance. This could be met by either increasing the battery power or suitably increasing the diameter of the conductor, though neither of these are desirable expedients. The greater difficulty is due to the leakage of current which takes place, leakage not merely from line to earth, but also from one line to another. Attempts to treat this by increasing the battery power merely aggravate the trouble, and it is found best to work with the smallest practicable current. The sounder, which requires what, in telegraphic practice, is a very heavy current, is therefore removed from 1, 2, and its place taken by an electromagnet built on much more delicate lines, and only requiring about one-sixth of the sounder's current. The sounder and a local battery are then connected to the armature of this *relay*, as it is called, so that when a current affects the relay, the relay closes the circuit of the sounder. This is shown in principle in 30, which represents the relay in the

line circuit, and the local sounder worked by a local battery and actuated every time that the armature of the relay moves from 2 to 1 under the influence of a line signal. Early types of relay were designed on the same lines as the sounder, but improvements in design have evolved much better forms.

In the sounder we notice that the magnetic field developed by the current must be strong enough to overcome the tension of a spring, and moreover that just at the point where we require the maximum force to begin the movement of the armature, the magnetic force is at a minimum owing to the large air gap. Out of a considerable number of modern forms we need describe only the Post Office standard relay. Like the sounder, it has two coils of silk-covered copper wire, but they are much longer, and are not connected by a yoke at the bottom. Its absence reduces the electromagnetic inertia of the instrument and therefore tends to greater rapidity of action.



28. DIRECT S.-C. SOUNDER

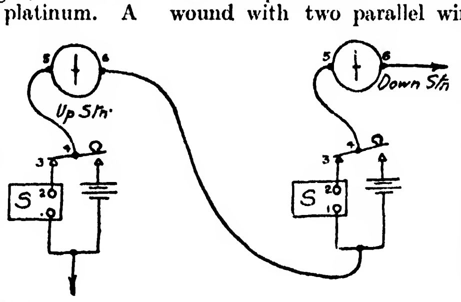
The cores of the coils are of carefully annealed soft iron, and they are provided at each end with soft iron pole-pieces, as shown in 31.

Two armatures are provided, one playing between the upper pair of pole-pieces and one between the lower pair. They are, however, rigidly attached to the vertical axle, which also carries the contact arm or tongue, made of German silver and tipped with platinum. A large and powerful horseshoe-shaped permanent magnet is placed with its poles adjacent to the armatures, S above and N below. To enable a circular cover to enclose all the parts, the magnet is bent round the coils.

The student has considered [on page 560] the distribution of magnetic fields, and he can see that in this case the lines of force will emerge from the N pole of the permanent magnet, and enter the bottom soft iron armature. At its further extremity they will divide into two streams. These will pass up the iron cores of the electromagnets, and, reuniting at the top, reach the S pole by way of the upper armature.

When the armatures are midway between the pole-pieces, they are in a position where there is what may be called *unstable magnetic equilibrium*. Two sets of forces are acting on them, tending to pull them over to one side or the other. If, now, a current be sent through the coils, this delicate balance is upset, because the lines of force due to the coil's field act so as to increase the force acting on one side, and to decrease the force on the other side. To illustrate this, the parts are distorted and laid out flat in 32. In the case of the sounder we saw that the armature was maintained in its normal position by the tension of a spring. This spring is not needed in the relay, because, by placing the armatures so that they are normally nearer to, say, the left side, we produce what is called a magnetic bias. The side with the smaller air gap has the greater magnetic flux. The armatures are therefore adjusted so that normally they lie to the left. Under the influence of a signalling current, they move over in the direction of the right side, but the movement is limited by the "marking" contact screw, so that the centre point is not passed. When the signalling current ceases, the armatures return to the left, under the influence of the magnetic bias.

The end of the tongue plays between the two contact screws S (spacing side) and M (marking side) [33]. These are attached to a little ebonite platform, which is in turn attached to a brass carriage sliding in a slot in the brass table which covers the coils. Under this brass table a spiral spring, Q, is fixed, and connected to the contact carriage, so that it tends to pull it to the left. A vertical brass lever has its top end connected to the contact carriage, so as to control its movement. The bottom end of the lever lies against the end of the adjusting screw, A. The position of the carriage is therefore adjustable by turning A. This determines the magnetic bias. The only other adjustment is the "play"—that is, the distance between the S and M contact screws. It should be noted that in connection with the latter there are small blue check screws, which have to be slackened before any adjustment can be made, and tightened afterwards to preserve it. Each coil of the relay is wound with two parallel wires, and these are connected to terminals, as shown in 31. The coil terminals are marked D, Ⓓ, U, Ⓤ. Brass straps are provided so that D may be joined to Ⓓ, and U to Ⓤ, in which case the relay is joined in parallel or quantity, or else both brass straps may be used to join Ⓓ to U, thus joining the coils in series.



29. STUDENT'S DIAGRAM OF A SOUNDER CIRCUIT

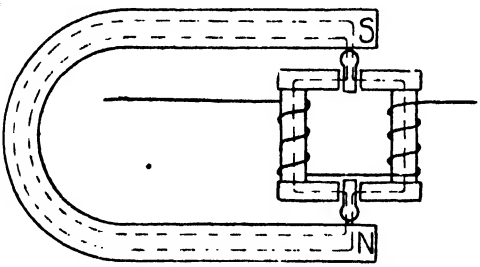
The student should specially note and memorise the fact that a current entering at U or Ⓤ, and leaving at D or Ⓓ, *marks*. He should also note that if a current be sent through one coil from U to D, and an equal current through from Ⓓ to Ⓤ, the armature will be unaffected. From this fact this method of winding is called *differential*. There are two forms of relay, alike except in resistance. In the A form, each coil has a resistance of 200 ohms, making 400 ohms in series, and 100 when in parallel. In the B form each coil has 100 ohms resistance, and so we have 200 ohms in series, and 50 ohms when joined in parallel. Fig. 34 gives a diagram of a sounder circuit with relay. It will be observed that the relay takes the place of the sounder at 1, 2. Fifteen to twenty milliamperes is

the usual working current. Small Daniell cells are employed for the main battery, and large Daniell cells for the local battery.

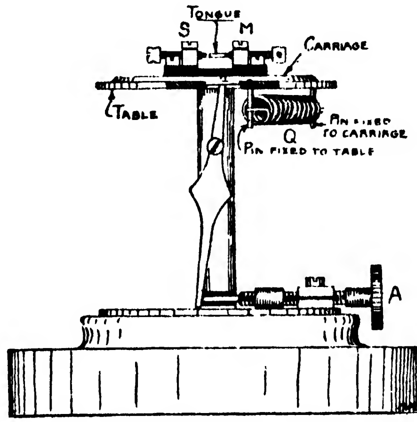
Printer or Inkwriter. Fig. 35 is a diagram of the connections of the printer, or, as it is sometimes called, the *direct writer*. It was illustrated and described on page 4383. The galvanometer (30 ohms), the receiving coil (300 ohms), and the key are mounted on one base, which also serves to carry the slip roll.

Small Daniell cells are usually used on printer circuits, the working current being about 17 milliamperes. The slip should travel at 6 ft. to 7 ft. per minute.

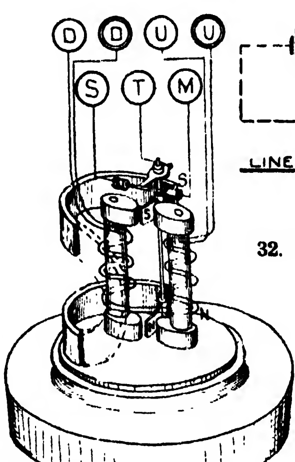
with his right hand a small crank. Normally, the needles of both sending and receiving instruments are at +. The generator is not connected to the line, even when the generator handle is revolving, until another key, say D, has been depressed, and the sending pointer moves round from + to D. It is only during this interval—*i.e.*, while the centre pointer is moving round—that the generator is joined to the line wire. It sends out a series of positive and negative currents, one current for each letter passed by the needle. Immediately the needle reaches D the generator is cut off the line. At the receiving end there is an electromagnet and



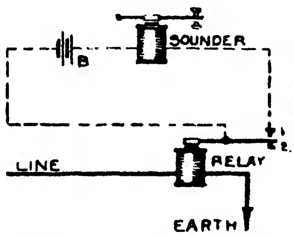
30. MAGNETIC CIRCUIT OF RELAY



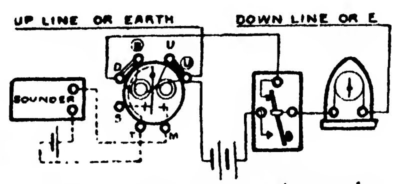
33. P.O.S. RELAY ADJUSTMENTS



31. P.O.S. RELAY—CORES, COILS, AND TERMINALS

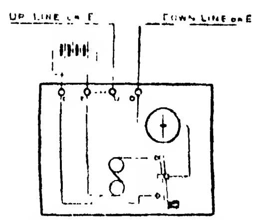


32. PRINCIPLE OF RELAY



RELAY STRAPS ARE ARRANGED FOR 'PARALLEL', FOR 'SERIES' BOTH STRAPS ARE JOINED BETWEEN (D) AND U

34. SOUNDER CIRCUIT WITH RELAY



35. PRINTER OR DIRECT WRITER

Wheatstone's ABC. As already stated [see page 4384] the manipulation of this instrument is very easily acquired. As a result, it at one time was rapidly coming into extensive use on private wires. The invention of the telephone, however, interrupted its career, and its use is now mainly confined to small and remote country post-offices, where the fact that only one wire is needed gives it an advantage from a financial point of view.

No batteries are used, the sending currents being generated by a small dynamo, power for which is supplied by the operator, who turns

armature very similar in arrangement to the P.O.S. relay just described. Instead of a tongue, however, there is an escapement wheel controlling the needle of the receiving dial in such a manner that for each current received the needle moves forward one letter. The letter at which the needle stops is noted down by the receiving telegraphist.

For instance, to send the word "Do," we should have:

LETTERS	ABCD	NEEDLE STOPS	EFGHIJKLMNO	NEEDLE STOPS	PQRSTUVWXYZ . . . +	NEEDLE STOPS
CURRENTS	+ − + −		+ − + − + − + − + − +		+ − + − + − + − + − + − +	

Continued

Group 29 **TRANSIT** 21 RAILWAY MANAGEMENT continued from page 4814

RAILWAY MANAGEMENT continued from page 4814

MERCHANDISE TRAFFIC

Railway Waggons. The Carriage of Goods. Consignment Notes. Railway Rates. The Delivery of Goods by Horse Waggons and Motor-cars

By H. G. ARCHER

WHEN the man in the street speaks of a goods train he has in his mind a train conveying either merchandise or minerals, and does not pause to differentiate between what really form two distinct classes of traffic. To a certain extent he is warranted in confusing the two. For the purpose of classification, *goods* are defined as anything entering the Railway Clearing House Classification Schedules A, B, C, and Numbers 1, 2, 3, 4, 5, the basis of which classification is their value or the cheapness with which the articles can be conveyed, while other factors that are taken into consideration may be summed up as weight and bulk, method of packing, and liability to damage. Further, the Clearing House "Rules and Regulations" only speak of a "goods train," which "is understood to include all trains except those composed of coaching stock." However, in practice, the mineral traffic is a thing apart, and it may be defined as covering the transport of coal, coke, iron ore, and patent fuel, while some companies also include in it granite, slag, and limestone—in short, the heavier and cheaper articles. The mineral traffic conveyed annually by the railways of the United Kingdom now amounts to 350,000,000 tons, and this traffic consists largely of coal.

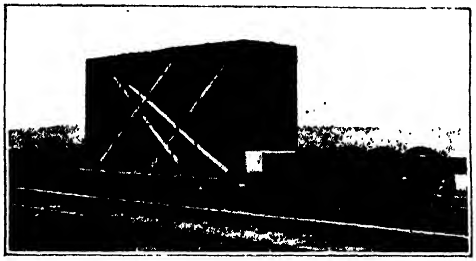
50. A LIFEBOAT POISED ON A RAILWAY WAGGON

Private Ownership of Waggons. The first railways were constructed, like the canals, with the idea of the motive power and the moving or rolling stock being supplied by the public. The railways were to be improved roads, for the use of which customers were to pay tolls, and the large number of traders' waggons in use is a substantial reminder of the original idea.

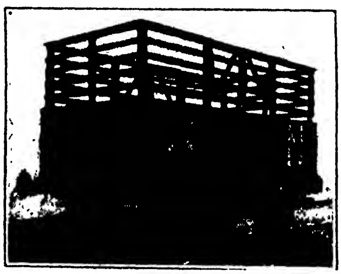
Formerly, private owners' waggons were a fruitful source of trouble and anxiety. A railway company in building its stock has too much at stake to risk sacrificing efficiency to economy, but the same conditions do not apply with equal force to private traders. In 1881, the Midland Company decided upon the new policy of becoming owners of nearly the whole of the waggons running upon their railway. Accordingly they obtained power to raise a large sum of money with which to buy up the traders' waggons by tens of thousands, the object being to raise the standard of such vehicles and to increase the safety of the line. Shortly afterwards, the Board of Trade intervened, by issuing a "standard specification" for ensuring uniformity in size, construction, and maintenance. Therefore private owners are compelled to build their waggons strictly in accordance with the standard specification, the provisions of which have been revised from time to time to meet up-to-date requirements. Further, before any waggon is accepted for conveyance on its own wheels, it must be examined and passed as sound by the locomotive or waggon department, after which a register plate, bearing the name of the company, the registered number, the date of registry, and the maximum load to be carried, is affixed to each side. The waggon is then free to work over the company's or any other line of railway, the arrangement being a mutual one between all the railway companies in the kingdom. As a result, to-day there are probably as many private owners' waggons on the Midland as on any other railway.

Varieties of Vehicles. All mineral waggons are open trucks, whereas merchandise waggons may be broadly divided into the *open truck* and what is variously termed the *box van*, *covered waggon*, or *cupboard truck*. There is, in addition, a large assortment of specially fashioned vehicles for special purposes—namely, cattle trucks, fish waggons, refrigerator vans, gunpowder vans, ballast trucks, plate glass waggons, trucks for the conveyance of timber in long lengths [50], low-bedded trucks, nicknamed "crocodiles" [51], for transport of anything abnormally high or heavy, such as boilers and machinery, and special "fender" waggons for straw hats and feathers [52]. The transportation of practically all merchandise and minerals in this country is effected by the means of vehicles—open or closed—carried on two axles and four wheels, and having doors at the side adapted to cart level. The mineral waggons have, as a rule, a slightly larger capacity than those intended for merchandise, but some companies discountenance any difference, as they wish all their waggons to be interchangeable. The standard British merchandise and mineral waggon is the 10-ton open truck (a truck being described according to its capacity and not by its tare, which is the weight of the

vehicle unloaded). The open truck began with one plank at each side, which has been gradually extended, with a view to obtaining larger loads combined with greater safety, to a height of from 3 ft. to 4 ft. Closed waggons are not so popular in this country as elsewhere. There is the difficulty of getting a crane into them, unless provided with a sliding roof, which in turn is liable to admit wet; on the other hand, they obviate the necessity of sheeting. Many companies are, however, considerably increasing their stock of box vans, and the cubical contents of the new vehicles, with which the sliding roof is abandoned, are twice as large as those of the old ones. It is customary for railway companies to give their own waggons distinctive marks. For instance, the London and North Western mark is a white diamond, the Lancashire and Yorkshire a triangle within a circle, the North Staffordshire the Staffordshire knot, and the Great Central a star. The tarpaulin sheets of open waggons also are distinctively marked, as a safeguard against loss or theft. Thus, the Midland is a black sheet with an orange border, while the Great Western sheet is scored with crossed bars and griffin's wings. Lastly, every company has its ropes made up with differently coloured strands, though this distinction is not visible unless one of the standard ferrules affixed to each end be lost.



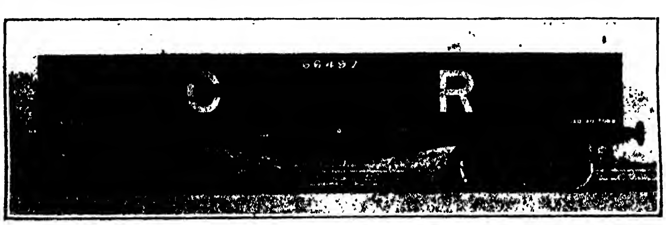
51. LARGE TANK ON LOW-BEDDED TRUCK



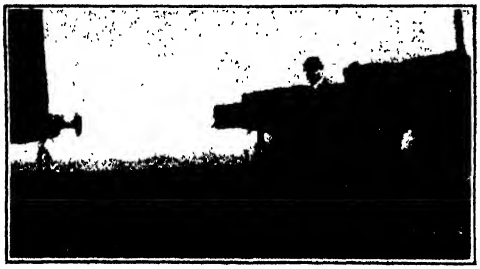
52. SPECIAL WAGGON FOR STRAW HATS AND FEATHERS

High-capacity versus Low-capacity Waggons. During the last few years a great controversy has been raging, and is still raging, relative to the desirability of increasing the capacity of mineral waggons. The average capacity of these vehicles now is 10 tons, and waggons larger than this are considered high-capacity trucks. The exponents of the high-capacity waggons—a vague term, as it covers anything between 15 tons and 40 tons—allege, with some truth, that owing to the low-capacity system, British railways are hauling considerably more dead weight, capacity for capacity, than is the case in some other countries, notably America. Their line of argument is that the adoption of high-capacity mineral waggons would considerably reduce the foregoing source of expense, and, at the same time, tend towards reducing the length of trains, because, given a uniform wheel base, there would be fewer waggons. However, several technical difficulties stand in the way of the adoption of larger waggons. In the first place, it must be remembered that all turntables, sidings, coal drops, weighbridges, pit screens, etc., at collieries, stations, and wharves, are designed for the low-capacity waggon. The wholesale alteration of these appliances and accommodations would be a most costly business, while another obstacle is that in the majority of instances they do not even belong to the railway companies, but to private traders, or corporate bodies, which could not be compelled to bear the expenses of the change.

Generally speaking, the traders are not enamoured of the advantages claimed for the high-capacity waggon. They fear damage to their small trucks when working with larger ones, and they scent damage to minerals while loading and being conveyed in the latter. Colliery owners carefully guard against breakage of coal, as freedom from "small" enhances its sale. There can be no doubt that there is much greater risk of breakage in loading fuel into large trucks, and also during its transit in the same. Iron ore, again, is said to be depreciated in value when carried in large trucks, for similar reasons. In the case of companies, like the Midland and North-Eastern, which prefer to own all the waggons running over their line, and also desire to make them interchangeable, the employment of two different sizes of waggons, for merchandise and mineral traffic respectively, is deprecated. The higher the capacity of a waggon, the longer it takes to unload, as only one checker can be employed at this end. Now it does not much matter what length of time the unloading of minerals occupies, but the case is very different where goods are concerned, as such consignments must be dealt with expeditiously. Suppose a 40-ton truck be fully loaded with goods, it would take many hours to unload, whereas a 10-ton waggon can be disposed of within the hour. On the other hand, this loss of time would probably be met to some



53. HIGH-CAPACITY 30-TON MINERAL WAGGON, CALEDONIAN RAILWAY



54. SHUNTER WITH COUPLING POLE, L. & N.W.R.

extent by better working. However, setting aside the question of effecting interchangeability, the crux of the problem rests on the fact that in this country there are very few cases which warrant the running of high-capacity mineral waggons—much less high-capacity merchandise waggons. In comparing our methods with those of other countries, it must always be borne in mind that there are important restrictions here which do not exist elsewhere. The industrial conditions of this country require small consignments and a "short haul." In America trains of fully-loaded 30-ton or 40-ton waggons are despatched across the continent, and are not broken up until they reach their terminal.

55. PAIR-HORSE VAN WITH LOAD OF EMPTIES

British Short Haul Conditions. A British mineral train rarely travels for a greater distance than 200 miles, and the coal consignments rule comparatively small. For example, it is estimated that on the London and North-Western 80 per cent. of the coal is carried in consignments of less than 20 tons; and, accordingly, there would be no economy in employing 20-ton waggons for the transportation of 80 per cent. of the traffic. Nevertheless, there are some openings for high-capacity waggons. Coal passing in large quantities for locomotive use, and a regular traffic between specific points in coal, ore or bricks can be conveyed in 30-ton or 40-ton trucks with advantage. Several companies have built waggons of this description for those special purposes [53]. When a waggon attains a capacity of 30 tons it must be carried on bogies. To sum up, it is unlikely that the agitation in favour of high-capacity waggons will succeed as its exponents wish it to succeed, for the simple reason that the idea is based on economical conditions which do not prevail in the United Kingdom; but the movement has been of great value by demonstrating that trucks of a moderately increased capacity—namely, from 15 tons to 20 tons, are likely to ensure success, if the change be made gradually. The North Eastern Company now carry the major portion of their mineral traffic in four-wheeled waggons having a tare weight of 9 tons 13 cwt. and capable of carrying 23 tons, while many other companies are acquiring a stock of 15-ton to 20-ton mineral waggons. These waggons fulfil a want, and confirm the fact that a paying load up to 20 tons can be carried within reasonable dimensions on two axles and four wheels, and with a tare in a ratio of only 2½ to 1, which are results equal to anything achieved with the larger bogie waggons.

Either - side Brakes, and Automatic Couplings. In the technical equipment of goods waggons three points remain to be noticed. First, there is the question of providing them with either-side brakes. Secondly, there is the question of fitting them with automatic couplings, which change, like the former, might any day be imposed upon the companies by the Board of Trade under the Railway Employment (Prevention of Accidents) Act of 1900. It is alleged that the present coupling pole and coupling system [54] have caused accidents to some 20,000 railway servants during the past 25 years. The delay in enforcing this provision is due solely to the difficulty experienced in finding suitable apparatuses. Hundreds of automatic couplers have been invented, but the genius of the inventor has gone unrewarded in so far as practical application is concerned. Thirdly, the "dumb" buffer is doomed, although the date appointed for its final abolition is not until January 1st, 1910. The damage which occurs in the shunting yards when these old, solid, dumb-buffered waggons are used in conjunction with those having spring buffers is very considerable, and causes a vast amount of otherwise unnecessary repairs. Many accidents on the line can also be attributed to the use of the former buffers, and the decision to supersede them is viewed with great satisfaction by all railway men.

Definition of "C and D" Rates. The cardinal point of difference between the goods and passenger traffic is the very obvious fact that the former does not find its

56. SUBTERRANEAN STABLES AT KINGS CROSS, G.N.R.

own way to and from the railway, neither does it transfer itself at junctions. In the former case there are two ways of dealing with the articles, either they are collected and delivered by the railway company, when they are charged "C and D" rates—that is, providing for the expense of collection and delivery—or they are brought to and from the terminal stations by the traders, who also undertake all loading and unloading. In the latter case "station to station" rates are charged, and all station to station consignments are carried in full truck-loads, as far as possible. Cartage is provided for in two ways; a railway company either employs its own horses, vans, lorries, and men, or commissions an agent to carry out the whole of this work.

The Cartage of Goods. The staff of the cartage department comprises the following: van boys, van drivers, stablers, van washers, van mechanics, cartage superintendents or inspectors, horse managers, and veterinary surgeons. Van boys are employed only in large towns, where the police regulations do not allow vehicles to be left unattended, and goods run the risk of being stolen from the rear of the vehicle while in transit. In course of time a van boy becomes a single-horse van driver, and is subsequently promoted to the charge of pair-horse [55], three-horse, and four-horse teams. In certain districts, where very heavy and bulky articles have to be handled, two men are sent out with each van, so as to assist one another in lifting the weights. Some companies call the second man a "book carrier," as he is responsible for receiving moneys and getting the book signed, while his companion, the carman or driver, is in charge of the horses. Companies undertaking their own cartage give the drivers and van boys uniform caps and overcoats, in order to act as an advertisement and protect customers from fraud, while some companies compel their cartage agents to do likewise.

In London and all big towns the major portion of the "C and D" goods—that is, the orders, go through the companies' receiving offices. The staff of a receiving office comprises an agent, clerks, and porters. On the other hand, in the country consignments (as a rule) are collected to order at the consigner's premises and taken straight to the station. The employment of self-propelled vehicles in the cartage department is dealt with later.

59. SHUNTING WITH HYDRAULIC CAPSTAN

57. GIVING OXYGEN TO A SICK HORSE

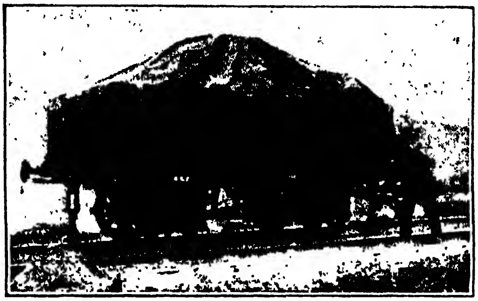
The Care of the Horses. The carmen at small stations have to groom and stable their horses, and also to wash their vans. All this is, however, done for them at important goods depôts, where the number of horses employed runs into hundreds and the stables, in consequence, form a separate establishment. In the case of depôts situated in the heart of large towns, the absolute necessity of keeping the animals near at hand compels them to be stalled on the upper floors of warehouses, in the arches of bridges, and even in subterranean labyrinths [56]. Here there are a horse manager, who is entrusted with the health, care, and feeding of the horses (although he does not select what horses are to pull what loads); a veterinary surgeon, with hospital staff; foremen horsekeepers, each of whom has charge of ten horses; stablers; van washers; and van mechanics, for every van is overhauled before making a journey. Moreover, at these depôts there is a cartage inspector who is a salaried official under the station-superintendent or the goods agent. It may be noted that cartage exigences necessitate the employment of different kinds of horses at different places. Thus, in London, good trotting horses are mainly required, whereas in Liverpool strong draught horses to pull very heavy loads at walking pace are essential. The work in the metropolis is of such an arduous character that some companies relegate their horses to country stations after six years of city work.

58. HORSE IN BLOOMERS

All companies have horse hospitals, where the last word of veterinary science is practised upon the inmates. The refinements of the treatment include the administration of oxygen inhalations to stimulate the action of a weak heart [57], while for applying hot fomentations the horse's legs are enveloped in "bloomers" made of several thicknesses of felt, and the "bloomers" are packed with hay which has been dipped in almost boiling water [58].

Consignment of Goods. Let us now describe the procedure followed when a package or a consignment of merchandise charged at "C and D" rates is handed to a railway company for transit.

The consigner fills in a document known as a *consignment note,* in which he describes the consignment for classification rates, states who pays the cost of carriage—consigner or consignee—and signs the ordinary conditions of the Carrier's Act, printed on the back. There are special consignment notes for special kinds of consignments, such as inflammable liquids, bullion and specie, explosives, damageable goods, etc. On arriving at the depôt the carman drives over a weighbridge, which registers the weight of his load in bulk. The reason for taking this weight is to furnish returns of the tonnage entering and leaving the yard, to prevent pilfering, and for the purposes of the bonus system, by which the wages of the carmen are regulated.



60. FOREMAN SHUNTER UNBRAKING WAGGON

The Work of the Goods Staff. The articles next pass into the hands of the working goods staff, which includes the following:

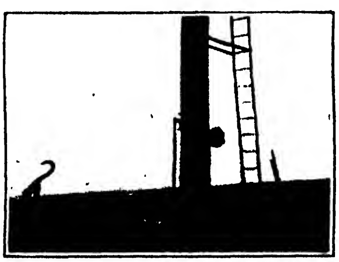
INDOOR WORKING	OUTDOOR WORKING
Porters and Checkers	Capstanmen
Loaders or stowers	Shunters
Callers-off and Searchers	Truck-markers
Shed Foremen	Number-takers
Inspectors	Yard Foremen

The carman gives his consignment notes to a checker. The latter checks the address of each consignment as it is communicated to him by a caller-off during the unloading process, notes whether or not the package or article is in good condition, weighs it, enters its weight on the consignment note, and transfers it, together with the consignment note, to a porter, with instructions as to its destination and the waggon into which it is to be loaded. A goods porter wheels the consignment to the appointed section of the shed or to where the proper waggon is standing, and here it is taken over by the loader.

The Science of Loading. There is considerable art in stowing or loading waggons. The consignments must be stowed in the sequence in which they are to be unloaded, and they must be distributed evenly over the floor so as to ensure an even weight on the bearings, otherwise the axles might run hot. An experienced loader will stow 3 tons where an untrained man would find difficulty in storing 30 cwt. Further, in the case of open trucks, the goods must be packed so that when the truck is sheeted the whole erection will be ark-like in shape, thus allowing rainwater to run off. The loaders are responsible, first, for the safety, and secondly, for the size of the loads.

Invoice System. Meantime, another checker has added the number of the waggon to the consignment note, after which it is sent up to the invoicing or "shipping" office. An invoice is then prepared, showing the forwarding and receiving stations; the number of the waggon in which the consignment is loaded; the point to which it is loaded: the route by which it is to be conveyed; the names of the consigner and consignee; the number and description of the packages, together with any marks (for some merchandise is conveyed under specific marks); the weight, showing whether carted, non-carted, or mineral; the rate per ton; the charge, whether it is "paid" or "to pay"; and any charges other than those for actual carriage, such as shippers' fees, agents' fees, etc., technically known as "paid on," if it is to be charged forward. The invoice either accompanies the goods themselves by being handed to the guard of the train that conveys it or by being affixed to the waggon side, or it is sent by post. At any rate, the invoice is supposed to reach the receiving station—that is, the station to which the consignment is loaded, by the time the goods arrive there.

The System of Loading and Transferring. The shed foreman is really responsible for the proper loading of the waggons with safety, efficiency, and economy. He has to see that two waggons are not used where one would suffice, and that before leaving the shed each waggon is properly sheeted, doors shut, and everything safe for it to proceed on its journey. The shed foreman is the goods agent's deputy and right-hand man, but at the more important depôts he has an inspector over him. The system of loading goods is as follows. When there is not a sufficient number of articles forthcoming to make up a full truckload to one destination, a truck is fully loaded to what is termed a *transfer point,* where the goods are re-sorted and combined so as to give good loads on to their respective destinations. On coming to a transfer point with another company, the fully loaded trucks containing heavy consignments are passed through, while the smaller consignments break bulk, and perhaps have to be carted some distance. A few of the great junctions—Crewe, for example—have tranship sheds where nothing but the work of transferring goods from train to bench and from bench to train is carried out. In the case of smaller consignments, the weight



61. CHAIN DRAG AND HOOK FOR ARRESTING RUNAWAY WAGGONS

of which is too light to warrant the running of a special truckload, the station truck system is employed. These latter trucks do not travel for long distances, and they work regularly on local goods trains which call at every station en route.

"Inwards" Traffic Methods. Having explained how the "outwards" or forwarded "C and D" traffic is dealt with, it will be understood that the procedure with the "inwards," or received, is mainly a reversal of the foregoing, with one or two refinements added. For example, immediately on the arrival of a main line train at a big depôt, it is met by a "truck marker," who, from particulars supplied by the delivery office, chalks for their proper discharging berths those waggons containing "order goods" (to await orders) or full loads. Again, waggons containing goods for districts that can be more advantageously dealt with by another station, or for which forwarding instructions have been received, are also re-labelled by the truck marker, thus saving unnecessary shunting and delay. Many vexatious incidents arise to interfere with the smooth working of the traffic, and the chief of these may be classed under four heads—namely: (1) goods arriving without invoice; (2) discrepancies between the invoice and the goods actually received in the waggons; (3) invoices arriving without the goods; (4) goods accidentally trucked to the wrong position on the shed platform. Special cut-and-dried methods are applied for rectifying each of the above errors, and in the case of the last named, the services of skilled men, known as "searchers," are requisitioned.

62. G.N.R. EXPRESS GOODS TRAIN

Arrangement of Goods Depôts. The special accommodation provided for dealing with the merchandise traffic naturally varies in size and equipment according to the volume and description of the goods to be handled. In ordinary circumstances, this accommodation is situated adjacent to a passenger station, but in large towns there are distinct goods stations or depôts, which, as a rule, are located as near as possible to the centres of trade and industry, although they may be some distance away from, but, of course, physically connected with, the main line of the railway company. For example, in London the City depôt of the London and North-Western Railway is at Broad Street, which is reached by means of the North London Railway *viâ* Camden and Dalston; that of the Great Northern Railway at Farringdon Street; that of the Great Western at Smithfield; and that of the Midland at Whitecross Street—access to all the latter being obtained over the Metropolitan line. The peculiar accommodation set aside for goods comprises sheds, warehouses, cattle pens, turntables, and sidings. The arrangement of sheds and warehouses has always been a subject of controversy. No standard principles exist, for every company has evolved its own scheme as best suited to its peculiar requirements. Broadly speaking, however, the laying out of goods accommodation must be governed by the exigences of the three different kinds of traffic into which the question resolves itself—namely: (1) local traffic (traffic which begins or ends its journey at the station); (2) transfer traffic (traffic loaded to the station for the purpose of being transhipped into other waggons and forwarded to destination); and (3) warehouse traffic (traffic in goods which are to be stored, awaiting orders for forwarding or delivery). A shed that deals with both receiving and forwarding traffic must clear out the former early in the day, so as to be able to dispose of the latter at night. The "rush" hours at an important goods depot are from 3 a.m. to 8 a.m., between which hours the "inward" traffic is steadily arriving, and from 6 p.m. to midnight, when the outwards traffic is being despatched. In the case of depôts like Camden, where several thousands of tons have to be disposed of every twenty-four hours, one section must be completed before it is possible to tackle the other. A typical big goods shed consists of an array of platforms, with lines of way on each side on the ground level, and an upper floor devoted to storage or office purposes; while underneath the shed lines are capacious cellars for the storage of beer, bacon, hides, and such commodities as can be lifted or lowered direct between the cellars and the carts, or railway waggons, by means of suitable cranes. It will be understood that the shed lines are used only for the loading and unloading of ordinary goods carried at "C and D" rates, which comprise all fragile or damageable articles, the mineral traffic, together with "C and D" consignments of greater weight or bulk, being dealt with in the open, where more powerful cranes can be installed. A large goods shed is mapped out so as to facilitate the work of the carmen, porters, loaders, and checkers. The walls of the cartage space bear number plates, corresponding to the numbers of the various districts into which the collecting and delivery area is divided; thus each driver knows where to station his dray. The platform pillars are hung with destination boards for the information of the goods porters and loaders, and the right waggons will be found opposite their respective boards. Lastly, to facilitate the handling of the articles power or

hand-worked cranes are liberally provided on the loading and unloading platforms for both carts and railway waggons.

"Mileage" and "Running" Sidings. The lines of way in the open are divided into "mileage" sidings and "running" sidings. The former, which are arranged in pairs, with room for a roadway between each pair, are utilised for the loading and unloading of "station-to-station" consignments, together with abnormally heavy "C and D" consignments. The "running" sidings are groups of lines for shunting operations, and not for the reception or delivery of goods. All shunting is performed either by engines, hydraulic or electric capstans [59], horses, or gravitation, with the assistance of the staff of shunters, whose grades are superior foreman, foreman shunter, shunter, and assistant-shunter.

The Goods Shunter's Arduous Task. The chief yard foreman is responsible for the shunting operations, but he delegates his responsibility to the superior foreman. The latter must be an intelligent man thoroughly conversant with the geography of the railway. His art lies in accomplishing the greatest possible amount of work in the minimum number of movements. Shunting is arduous and dangerous work. The men are out in all weathers, and are exposed to serious risks of being run over, as not only do the trucks move up and down the parallel lines of way in a constant stream, but in many yards they are transferred from one track to another by means of turntables and lines running at right angles across the yard. Formerly, shunters were exposed to further risk by having to get between vehicles for the purpose of coupling or uncoupling them, but the obligatory provision and use of shunting-poles [54] has obviated this. The object of shunting is, of course, to classify the outwards waggons in complete trains, to marshal them in district and station order in their trains, and to split up the inwards trains by picking out the waggons to be unloaded. The latter have then to be shunted into the goods shed or into the "mileage" sidings, where they must be properly placed for the trader to get at them easily with his carts.

"Dressing the Yard." In order to facilitate and economise the work of "dressing the yard," which at important centres is an operation of immense magnitude, difficulty, and costliness, schemes of marshalling sidings of elaborate construction and of great extent have been laid down. A very popular design is a fan-shaped yard, with a long shunting neck forming the handle of the fan, and occasionally the fan is double-handled, so to speak. All the sidings run into a common departure line, so that waggons can be drawn out in any order in which they are required to be marshalled, or a miscellaneous collection of waggons for different destinations can be broken up into sections in the trains, while sometimes the "fan" is laid out on a falling gradient so as to economise power.

"Dressing" by Gravitation. The latter plan was first put into operation by the London and North-Western Company at Edge Hill, near Liverpool, for the purpose of breaking up all goods trains arriving, and sorting out the waggons for the several depôts in the city, whence they are distributed to the various docks and warehouses, and, on the other hand, of assembling the waggons loaded at all the depôts, and subsequently classifying and marshalling them in trains for despatch in all directions. The sidings consist of (1) the reception lines at the summit of the incline; (2) the sorting sidings, into which the waggons, when separated, first run; (3) the "gridirons," through which the trucks are filtered, so as to make them take their proper order of precedence in the train; and (4) the departure lines, which receive the trains in their complete state, and where the engines are attached to take them away. On the arrival of a set of waggons in the reception lines, the rear brakes are applied, the engine is detached, and on each waggon a truck marker chalks the number of the sorting siding it has to enter. The waggons are then let down the incline [60], the shunters passing the number on by hand or lamp signal to the men who have charge of the points. This process gives each sorting siding a separate train, although the waggons composing it are in indiscriminate order, but by a repetition of the operation the waggons of each train are separated in the "gridirons," whence they are lowered one by one into the departure lines in their proper sequence. The gradient of such sidings varies according to the requirements. It may begin at from 1 in 40 to 1 in 60, and finish up at from 1 in 100 to 1 in 300. Much depends, however, upon the resistance to be overcome from points, crossings, or curves. All the curves are of the same radius, so that the resistance offered by each may be the same.

Arresting Runaways. The shunters are provided with brake-sticks, which they insert between the wheel and the frame to steady the vehicles in descending, and they also use these implements for letting down the brake-levers as required. Runaway waggons are arrested by means of a "chain-drag" apparatus [61]. This consists of a heavy iron cable, wound on a drum, which is placed in a receptacle between and below the level of the rails; a steel hook attached to the cable is fixed at the height of the waggon axle and is worked by a lever, which also works a signal. When the line is clear for a train to pass, the hook is kept lowered, but if it is desired to stop a waggon, the hook is raised and catches the axle of the waggon, and the heavy cable being drawn out of the tank by its weight, when dragged over the ballast, so brings the runaway to a standstill. The Edge Hill yard covers an area of 200 acres, comprises 57 miles of running lines, and deals with 3,000 waggons per 24 hours. The Great Northern Railway has a similar yard for the concentration of its mineral traffic at Colwick, near Nottingham, and the Great Central Railway is laying out a huge yard at Wath, in the South Yorkshire district. Traffic from 45 collieries, lying east, west, north and south, will be worked to Wath in the rough, to be sorted, marshalled, and worked away in full through trainloads, empty trucks being similarly collected there and

worked to the respective collieries. In connection with the yard there will be 36 miles of sidings, and the length from one far junction to the other will be 1¼ miles. It is estimated that when completed about 5,000 waggons can be dealt with in 24 hours at Wath.

"Number-takers." Before a goods train leaves the yard the chief yard foreman is responsible for seeing that the loads of open trucks do not exceed the limits of the load gauge (a load gauge apparatus, with swinging bar, is the safeguard), and that no timber-truck, boiler waggon, or other vehicle furnished with ropes or chains, is permitted to start without the ropes or chains being made secure and safe. In all important goods yards, and especially at junctions of any two companies, you will see officials examining the waggons and taking notes. These are the "number-takers" employed in jotting down the numbers and descriptions of all the waggons, and it is from their records that returns are made to the Railway Clearing House. Number-takers are employed by both the railway companies and the Clearing House, but some companies have discontinued the practice, or, rather, relegated the task to the guards, who enter the number of every waggon on the train in a special book.

Duties of Goods Guards. Every goods and mineral train is accompanied by a brakesman or guard, and sometimes by both, for the distinction is only one of grade, the former being a junior and the latter a senior guard. Goods guards are recruited from station porters, shunters, etc.

Although the guard of a goods train has no luggage or parcels to attend to, he is given plenty of occupation. He has to keep a log, or journal of his train, like the passenger guard; is responsible for the proper connection and equipment of his train, and has to see that waggons labelled for certain places are put off correctly, while at wayside stations he directs shunting operations. Except in case of emergency the passenger guard has nothing to do with the actual working of his train, whereas the goods guard, in travelling down steep inclines, must assist the engine-driver by applying the rear hand brake—care being taken not to skid the wheels—and where necessary, fastening down a sufficient number of hand brakes on the waggons. Guards must not take on waggons loaded with goods liable to be set on fire by sparks or cinders unless the waggons are properly sheeted. Such waggons must be placed as far as possible from the engine. Every goods guard who has used a van with a stove in it, must, before leaving duty, take care that the fire in the stove is entirely extinguished, unless the van has to be sent out again immediately, in which case a small fire may be allowed to remain. Goods guards must not leave their trains until they have been delivered over to the yard foreman, relief guard, or "train meeter." As the running of goods trains is subject to some incertitude, due to the fact that this traffic yields precedence to the passenger variety, special measures are devised in order to obviate the necessity of making the guards work unduly long hours. Goods guards depôts are situated at strategic centres of the line, and if a guard finds that he cannot get home within twelve working hours he may wire to the nearest depôt en route for a relief guard, and then, as soon as relieved, he may please himself whether he puts in a rest at the depôt barracks, or continues his homeward journey off duty. For the same purpose there is a staff of train meeters at all the principal terminal yards, the members of which relieve the guards of incoming trains, and finish up their work for them.

63. N.E. HIGH-CAPACITY MINERAL TRAIN EQUIPPED WITH WESTINGHOUSE QUICK-ACTING CONTINUOUS BRAKE

Limits of Load and Speed. The loads of merchandise and mineral trains are arranged according to the speed at which they are booked to travel, which, in turn, depends upon the character of the line as regards curves and gradients, and the power of the locomotives. The standard loads vary from 24 to 60 waggons. With the uninitiated, a misconception is prevalent that goods trains are worked anyhow, the only stipulation being that they do not interfere with the running of the passenger trains. As a matter of fact, the working of the goods traffic is as carefully provided for and supervised as that of the passenger, while it is infinitely harder to arrange, for the very reason that it is constantly being called upon to shunt out of the way of the faster traffic. Absolute punctuality is insisted upon, and errors and delays are the cause of searching inquiry. The major portion of the goods traffic is conducted by night, when there are few passenger trains running, which, of course, somewhat simplifies matters, while the

heavy trade companies have been at great expense to provide their main lines with an additional pair of rails to be appropriated to the goods and slow passenger trains.

Express Goods Trains. In this country the merchandise, as distinct from the mineral traffic, has ever been worked at comparatively high rates of speed, and the tendency now is to increase the speed of such trains until they fall little below that of express passenger trains. The Great Northern Railway was the pioneer of "express" goods trains [**62**], and at the time of writing boasts of giving a score of these daily, which are timed at inclusive speeds of from forty to forty-five miles per hour. A rate of speed exceeding fifty miles per hour is, however, often maintained from start to stop by trains conveying fish and other perishable consignments.

The faster-timed merchandise trains are composed entirely of new large-capacity cupboard waggons, equipped with oil-boxes, and an automatic continuous brake, while the most powerful express engines are employed to haul them [**63**].

Goods Rates. The charges upon a railway may be classified as rates, fares, and tolls. A rate is the cost per ton of hauling merchandise and minerals from one point to another; a fare is the cost per mile of carrying passengers in the company's own carriages from station to station; and a toll denotes "a tax or custom paid for passage," as when one company exercises running powers over the lines of another. Tolls may take, therefore, the shape of a fixed allowance per passenger, parcel, or ton of goods, or the amount may be determined by a mileage proportion of the receipts. In addition, companies are sanctioned to charge bonus mileage rates and fares for the use of special works, such as the Severn Tunnel, or Runcorn, Tay, and Forth bridges, the construction of which entailed expenditure out of the ordinary. For instance, the Severn Tunnel is 4¼ miles long, but the Great Western Company are authorised to charge for the use of it as though it were 12 miles in length.

The rates, fares, and tolls to be charged upon a railway are, in a sense, regulated by Act of Parliament and the maximum charges now authorised to British railways for the conveyance of merchandise and mineral traffic date from 1892, when, for the purpose of fixing charges, all goods liable to railway conveyance were classified under eight different heads, three of which are known as classes A, B, and C, and the remainder as classes 1 to 5. The system of classification followed still is, as it always has been, according to the weight, bulk, value, method of packing, and liability to damage of the articles. Class A traffic includes coal, coke, iron ore, patent fuel, etc.—in short, the heavier and cheaper articles which are carried at the lowest rates, while at the other end of the scale is Class 5 traffic, which covers furniture, china, straw hats, perfumery, etc.—in short, the more valuable or fragile articles, for which rates are naturally highest.

Important Rules. Classes A and B are applicable to consignments of four tons and upwards. In Class A the ordinary rate stipulates that the freighter shall supply trucks. If the railway company supplies trucks an additional charge is made. In Class B the normal rate applies to traffic in railway companies' waggons, and if the freighter supplies the waggons an allowance may be made. In neither A nor B do the rates cover any labourage. Class C is applicable to consignments of two tons and upwards, and the ordinary rate covers loading and unloading by the companies, but not cartage. Classes 1 to 5 apply to consignments of from 3 cwt. to 2 tons, and unless otherwise provided, the rates include collection and delivery within the boundaries prescribed by the companies at the various places. Consignments not exceeding 3 cwt.—technically known as "smalls"—are charged in accordance with the regulations and scales for small parcels by merchandise trains.

The Goods Clerk's Classic. The statutory classification of goods not being considered sufficiently comprehensive, the Railway Clearing House issues a "General Railway Classification of Goods by Merchandise Trains," which has been appropriately christened the "Goods Clerk's Classic." This latter volume is published annually, and a reduced specimen page out of the 146 which it contains is reproduced below.

GENERAL RAILWAY CLASSIFICATION OF GOODS, 1905. 71

	Class		Class
Iron and Steel—*continued*		Japanned Ware—	
Wheel Centres, *Locomotive* ..	C	*In casks, cases, or crates* ..	3¶
In less lots than 2 tons ..	1	*E.o.h.p.*	4
Wire (iron), not packed or wrappered	C	Japan Moss	3
Wire, *iron*—Staples (of iron wire) sent with Iron Wire to be charged at the same rates as the Wire.		Japan Wax	2
Wire, *steel*—Staples (of steel wire) sent with Steel Wire (to be charged at the same rates as the Wire.	1	Jarrah Wood—(*see* Timber, p 142)	
Wire (*steel*), *not packed or wrappered*	C	†Jars and Bottles, *earthenware or stoneware, packed or protected by wickerwork*	1
Wire, *wrapped in paper, canvas, or brattice cloth.*	C	*Not packed nor protected by wickerwork, Station to Station, minimum charge as for 2 tons per waggon, exclusive of labour, Owner's risk* ..	1
Wire Iron, *rolled in rods or coils, not packed*	C	†Jars and Bottles, *earthenware or stoneware, e.o.h.p.*	2
Wire Rope, *old, cut in pieces*	B	Jelly or Grease, *Petroleum*	3
Isinglass, *in casks or cases*	4	Jet	5
Isinglass, *e.o.h.p*	5	Jew's Harps	3
Istle, *for Brush-making*	2	Jim Crows or Benders (*for rails*)	1
Italian or Box Irons	3¶	Iodelite Oil, *in casks or iron drums, round or tapered at one end*	1‡
Ivory Waste or Dust	2	*E.o.h.p.*	3
†Ivory, *e.o.h.p*	5	Joiners' Tools	3¶
Ivory, *Vegetable, packed*	2	Joiners' Work (*common wood*)—Beadings and Mouldings (*not gilt, lacquered, or varnished*), Doors and Door Frames, Fittings and Fixtures for Buildings, Staircases, Balusters, and Hand Rails, Window Sashes and Frames and Shutters	3y
" " *e.o.h.p*	3	Doors, Door and Window Frames, *made of Mahogany, Walnut, and other expensive Timber*	4y
Ivory Black, *in bags and casks*	*2	Joists, *iron or steel* (*Bridgework*)	*Ci
E.o.h.p.	2	Juniper Berries	3
J.		Jute	1
Jackets or Mantles, *Women's (not silk), in bales, packs, or trusses*	3	Jute Waste, *not oily, for paper making, hydraulic or steam press-packed*	C§
Jackets or Mantles, *Women's (not silk), e.o.h.p*	4	Jute Waste, *not oily, e.o.h.p.* ..	1§
Jacks—			
Bottle	3¶		
Screw, iron	1		
Screw, except iron	3¶		
Small	3¶		

* Subject to special arrangement when of unusual length, bulk, or weight, eptional bulk in proportion to weight
† If not properly protected by packing to be only accepted at Owner's risk
‡ Grocery List No. 1. § Paper-making Materials List. ¶ Hardware List.
Iron and Steel List. y Reduced rate at Owner's risk.

A part of the book is printed on yellow paper, which portion contains a special classification of explosives and other dangerous goods, while there is also a private supplement on pink paper which contains instructions for the information of

railway servants alone respecting the method of charging for articles of unusual length, weight, or bulk, articles requiring an exceptional truck or a special train, articles not packed or insecurely packed, any wild beast, and specie, bullion, plate, and statuary, etc. which the railway companies are authorised to charge "any reasonable sum they think fit." In the present statutory classification, Parliament, instead of providing for all unenumerated articles in the highest class, has placed them in Class 3; but an appeal is permissible on either side. Thus, if a freighter deems that a traffic in which he is interested be too highly placed in Class 3, he may apply to the Board of Trade to have it reduced, while, on the other hand, if the railway companies consider that its classification in Class 3 be too low, they may apply for it to be transferred into a higher class. A case in point is the recent successful application on the part of the companies to have gramophone records placed in Class 5.

Legal Restrictions Against Increasing Rates. Another "Railway and Canal Traffic Act," passed in 1894, renders it obligatory for the companies to prove to the satisfaction of the Railway Commissioners if challenged that any increase of rate made directly or indirectly since December 31st, 1892, is a reasonable increase; and for this purpose it is not sufficient to prove that the rate is within any limit fixed by Act of Parliament. The provisions of this latter Act have had the not unnatural effect of making the companies timorous of temporarily lowering during bad times what is a fair rate from fear of incurring litigation should it be subsequently restored to its original height when the depression has passed away.

Adjustment of Rates. In practice, the railway companies rarely avail themselves of their maximum charges. The principle of the companies is to charge what the traffic will bear—that is, rates based not on the cost of the service to the railway company, but on what it is considered the freighter can and ought to pay for it. Within their statutory maxima the companies are free to adjust their rates on a free commercial basis, subject to the foregoing provision regarding increase of rate. Thus, they may charge differential rates, in contradistinction to uniform mileage rates; but one thing they are debarred from doing is to establish a bounty system, or to give one trader undue preference over another. As to what constitutes undue preference is, however, a very thorny question. For example, different rates charged for consignments of coal, grain, and agricultural produce carried between the same points, one for export or import and the other for home consumption, are not deemed to exhibit undue preference, as in the former case what is invariably the lower rate is considered to be justified by the much larger volume and greater regularity of consignments carried to and from the ports than between inland stations.

Machinery of the Rates Office. The Head "Rates Office," which is entrusted with the making and keeping accounts of rates, etc., forms the busiest and most complex branch of the goods managerial department. Each district goods manager also has a "Rates Office," whose proceedings are regulated by the headquarters office, but which in some cases is empowered to fix local rates within the district without first referring them to headquarters. A rate book must be kept at each station, where any trader may inspect it on demand.

The head and other important "rate offices" are subdivided into three departments, one to deal with merchandise rates, another with mineral rates, and another with livestock rates.

Millions of rates, of course, are already in existence, while how they came to be so is best explained by recapitulating the procedure followed when a company receives an application from a trader to quote a rate between any two points not scheduled in the rate book, and perhaps for some newly invented article which is not found in the classification book. In the latter case, the first thing to be done is to decide how the article in question should be classified.

In calculating a rate, various interests are taken into consideration—the value, nature, size, and quantity of the consignment (the quantity, whether a few tons or several trainloads, being a most important factor), cost of service, consumers' interest, producers' or manufacturers' interest, possible competition by rail or water, possible competition from other produce districts, geographical disadvantages to be overcome, and margin of profit.

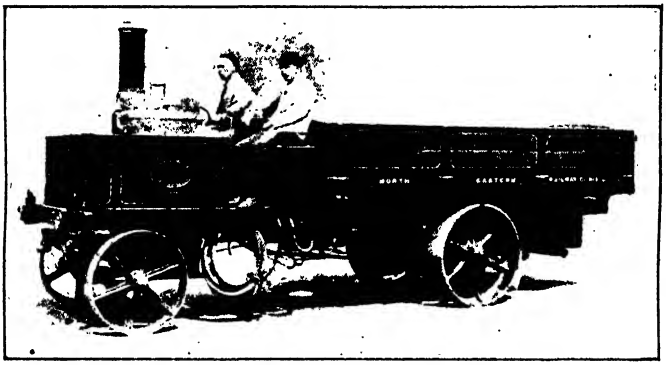
Fixing Through and Competitive Rates. Through and competitive rates—that is, those rates in which more than two railways are interested—are to a large extent governed by conferences. There is the English and Scotch Conference, which explains itself; the Normanton Conference, which controls almost the whole of the competitive rates in the North not dealt with by the former; the English-Irish Conference; the Birmingham and South Staffordshire Conference; the Metropolitan Conference; and a host of minor local conferences, such as the Mersey Ports.

Where only two companies are affected in the fixing of a through or competitive rate the rates clerks meet to discuss the matter, and both companies are bound to publish the agreed rate upon the same day. The analysis of a "rate" reveals that the maximum charge which may be made is set out under two heads—namely, (1) Station and Service Terminals; (2) Rate for Conveyance. A station terminal is the maximum charge for the provision of buildings (including warehousing during free period) and sidings, exclusive of coal drops; and a service terminal is the maximum charge for such labourage as loading, unloading, sheeting, and unsheeting merchandise.

The rate for conveyance is the actual cost of haulage, and this is based upon no hard and fast rules, although the axiom is "the shorter the mileage the higher the rate." At the chief rates office of a great railway company a complete record is kept of every calculated rate between

any two points, and the number of rates runs into many millions. At Paddington the rates library comprises upwards of 1,000 volumes.

It is a simple enough matter to ascertain from these volumes particulars about non-competitive or local rates between any two points, but none but an expert rates clerk can trace those of through and competitive rates, which are common to several companies. At headquarters a special "noting staff" of clerks is kept constantly employed entering up all new rates as they are issued, together with keyed references to the authority under which each rate was promulgated.



64. N.E.R. LONDONDERRY STEAM MOTOR WAGGON

A separate department exists for calculating and keeping account of the passenger train rates for parcels, etc. These rates are fixed by the superintendent of the line, or, in the case of the North-Eastern and Great Northern Railways, by the chief passenger agent.

How Disputes are Settled. There is a specially organised statutory department to deal legally with the various phases of controversy between railway companies, or questions of difference between a railway company and a canal company. This is the Railway and Canal Commission, which, in addition to the above, is empowered to adjudicate upon the question of through rates over different lines where such rates would be of public benefit; to hear and determine cases instituted by the consignor or consignee of merchandise against railways in respect of excessive or preferential rates and charges, insufficient accommodation and facilities, and as to any allowance or rebate to be made from the rates charged on the ground that the railway company did not perform terminal services; to order traffic facilities, notwithstanding existing agreements; and to apportion the expenses of erecting any improvement, such as a necessary bridge, subway, etc., between a railway company on one side and the applicants for the desired improvement on the other.

By the Act of 1888, under the powers of which the present Commission now sits, the department consists of two appointed and three ex-officio Commissioners. The Board of Trade appoints two Commissioners, one of whom must have had considerable railway experience, while the ex-officio commissioners have to be Judges of Superior Courts in England, Scotland, and Ireland. There are also a registrar and clerk to the Commission.

Automobile Transport of Goods. The question of the employment of mechanical road traction for the transport of goods, both heavy and light, is of great importance. Nevertheless, automobilism has not as yet materially affected railways where the cartage department is concerned; that is to say, it has not displaced horses to any appreciable extent in the collection and delivery of consignments carried under "C and D" rates. The chief reason for this is that, in order to render the use of self-propelled vehicles profitable, at least three factors must be present—namely, a fairly long haul, a full load of consignments for conveyance to or from a fixed point, and a clear road. Generally speaking, each of these factors is absent. Whether in country or town, the bulk of the business done consists of the cartage of goods and parcels over short distances, and through congested roads or streets, while the loads themselves are made up of miscellaneous consignments, which are collected or delivered at frequent intervals, thus entailing a great deal of waiting about. In congested thoroughfares a motor vehicle possesses no advantage in point of speed over a horse-drawn van, and it is obvious that to keep expensive machinery idle, and consuming fuel and water, during a constant series of intermittent halts must be a wasteful procedure

65. FIRST ELECTRIC LORRY IN ENGLAND

Another drawback is that nothing approaching the same amount of work can be got out of self-propelled waggons as from carts and horses. A team of horses can be employed on two or three consecutive trips. There are, say, 400 vans at a goods' depot: half the number can be loaded and sent out, and while they are away the remainder can be loaded up. Then, when the former return, loaded with "outwards" goods or empty, it is only a question of transferring the teams to the latter; whereas, with motor vehicles the motive machinery would have to be kept idle during both the loading and unloading processes. Again, motor vehicles are not so adaptable for drawing up into what chances to be the most convenient position for loading and unloading, and there are many warehouses in which, owing to the inflammable nature of

the contents, their presence would be resented as a source of danger. Lastly, if the railway companies were to adopt mechanical traction on a large scale they would be faced by the problems of providing stabling for the vehicles (carts can be left in the open), and of storing the petrol safely.

The conditions under which motor traction can be profitably employed are between important, self-contained collecting and distributing centres, and between the railway and depôts in towns or villages which lie a good many miles away. In the latter case, a service of passenger and goods motor-cars might prove an enduring substitute for a branch line of railway. Traction engines are to be preferred for very heavy and unwieldy loads, such as machinery, which would otherwise necessitate the employment of large teams, say, of a score of horses.

Different Types of Vehicles. The different types of motor waggons at present in use by railway companies are: steam waggons and lorries [64] for heavy goods transport—that is, for loads of from 5 tons to 8 tons; small steam traction engines, coming under the Motor Car Act; petrol lorries, for light goods and parcels transport, 2-ton, 3-ton, and 5-ton vehicles [66]; and electric vans [65], of about 2 tons capacity, for the expeditious delivery of light, perishable goods.

66. N.E.R. DURKOPP MOTOR PARCEL VAN

Steam possesses several advantages over petrol in the heavy goods service—namely, both the initial outlay and cost of maintenance are much less; the deliveries with this class of consignment being chiefly centred at one fixed point, fuel and water are not consumed to no purpose during intermittent calls; the pace being slow, iron tyres can be used; and there exists larger reserve power for emergencies. On the other hand, petrol is more advantageous and more economical than steam for light goods transport, and the carriage of mails and parcels.

All technical matters relating to road motor-cars are delegated to the department of the chief mechanical engineer, while the arrangement of the services and the supervision of the staff rests with the superintendent of the line, who acts in unison with the chief goods manager in arranging the goods car service.

Organisation and Staffing. The North-Eastern Railway has an officer attached to the chief traffic manager's department who has had a mechanical engineer's training, and he deals with everything connected with the road motors, communicating as follows: with the mechanical engineer upon mechanical matters; with the chief goods manager about goods matters; and with the chief passenger agent about passenger matters. He is practically a joint servant of these three departments, and if the head of any of them has a point which he cannot settle himself it is settled by the chief traffic manager.

The Great Western Railway, which was the pioneer of the adoption of mechanical road traction for railway requirements, and which possesses the largest stock of self-propelled vehicles of every description, has organised a special motor-car department, under the ægis of the superintendent of the line, to deal with cars all over the company's system. The headquarters of the department are located at Slough, and there, too, are shops that carry out nearly all repairs. The staff of the department consists of: (1) for indoor working, a chief mechanical superintendent, an assistant mechanical superintendent, a chief clerk, a keeper of retail stores, a tyres and staff clerk, who keeps a register of the mileage of all cars, and a travelling inspector of stores; (2) for outdoor working, a foreman fitter in charge of repair shops, a foreman driver, who arranges the services, a traffic inspector, and a staff of drivers, and conductors.

Selection and Training of Drivers. To begin with, the companies had to recruit for drivers from outside the railway service, but now they train their own drivers, and the more satisfactory drivers are the men whom they have trained themselves. Drivers are divided into four grades—namely, foremen drivers, leading driver, driver, cleaner-driver. A man is promoted foreman driver from the shops, and every important car centre is placed in charge of a foreman driver.

Candidates for the post of cleaner-driver must be from twenty to twenty-four years of age, although ex-locomotive firemen are accepted at a later age. A cleaner-driver receives a practical training in the elementary mechanism of motor traction, and when passed by the foreman he is allowed to drive one or two trips a day, to relieve an ordinary driver. In due course, he is promoted to driver, and then to leading driver, and in the latter capacity he becomes eligible to be given charge of a small car centre.

Continued

ITALIAN—FRENCH—SPANISH—ESPERANTO

Italian by F. de Feo; French by Louis A. Barbé, B.A.; Spanish by Amalia de Alberti and H. S. Duncan; Esperanto by Harald Clegg

ITALIAN

Continued from page 4918

By Francesco de Feo

ADVERBS—continued

Adverbs of Manner

come? how?
comunque (comoón-kooeh), however
così, so
bene, well
male, badly
appena, hardly
insieme (eensee-èhmeh), together
in fretta, in a hurry
volentieri, willingly
mal volentieri, unwillingly
all' improvviso, suddenly
gratis, gratis
a memòria, by heart
a mano a mano, gradually
etc., etc.

The termination *-oni* added to some nouns and verbs forms adverbs indicating position of the body, as:

bocconi, lying on the face, prostrate
penzoloni, *ciondoloni*, hanging down
a tentoni, groping
a cavalcioni, on horseback
saltelloni, skippingly

Other compound adverbs of manner are formed by understanding the words *moda*, *maniera*, *uso*, as: *All' inglese = secondo la moda inglese*, in the English fashion; *Alla francese = secondo l'uso francese*, in the French way, etc.

Adverbs of Quantity

molto, much
assai, much
troppo, too much
poco, little
abbastanza, enough, sufficiently
soltanto, only
niente, nothing
quasi niente, almost nothing
affatto, completely
di più, more
meno, less
presso a poco, nearly
etc., etc.

The student must not confound *assai* with the French *assez* = enough.

Adverbs of Time

allora (ahllò-rah), then
ora, now
oggi, to-day
domani, to-morrow
mai (màh-ee), never
spesso, often
prima, before
dopo, *poi* (pò-ee), after
appena, as soon as
presto, soon
tardi, late
quando? when?
da quando? since when?
adesso, *ora*, now
fra poco, shortly
or ora, just now
sempre, always
talvolta, sometimes
già (dgee-àh), already
poco fa, a little while ago
un mese fa, a month ago
un giorno sì e un giorno no, every other day
etc., etc.

Many adverbs have different meanings. Examples: *Quel poveretto appena* (manner) *si regge in piedi*, That poor man can hardly stand on his feet; *Appena* (time) *arrivammo fummo ricevuti*, As soon as we arrived we were received.

In familiar language *oggi* is frequently used for "this afternoon." Example: *La vedrò oggi*, I shall see you this afternoon.

The adverb *già* used as an adjective means "formerly," as: *Via Roma, già Toledo*, Via Roma, formerly Toledo.

EXERCISE XLVI.

1. Avete fatto bene a venire da me; io vi caverò facilmente d'impiccio. 2. Egli parla sempre modestamente di sè medèsimo. 3. Parlate chiaro, se volete che io vi ascolti. 4. Sfortunatamente arrivammo troppo tardi. 5. A poco a poco sormonteremo tutte le difficoltà. 6. Ditegli di aspettare; io verrò giù sùbito sùbito. 7. Probabilmente avremo una risposta stasera. 8 Era tanto bùio che andavamo a tentoni. 9. Il latore è un mio intimo amico; glielo raccomando particolarmente.

Adverbs of Place

dove, where?
donde, whence?
qui, *qua*, here
lì, *là*, there
qua e là, here and there
costì, *costà*, where you are
ecco, here is
ci, *vi*, here, there
ne, from here, from there
sopra, *su*, on
sotto, *giù*, down, below
lassù, up there
laggiù, down there
altrove, somewhere else
dovunque, everywhere
avanti, forward
dietro, behind
lontano, far
etc., etc.

1. Both *qui* and *qua* indicate the place where the speaker is; but *qui* defines the locality more closely than *qua*. Example: *Venite qua*, Come here; *Venite qui*, Come here (near me).

2. *Costì* and *costà* indicate the place of the person addressed, with the same difference as exists between *qui* and *qua*. Example: *Sarò costà domani*, I shall be in the place where you are to-morrow.

3. *Là*, *lì*, *colà* indicate a place where neither the speaker is nor the person addressed. *Lì* indicates a place nearer than *là*.

4. *Di qua*, *di qui*, *di là* mean this way, that way, and also this side of, that side of. Example: *Venga di qua*, Come this way; *Vada di là*, Go that way.

Adverbs of Order

primieramente, firstly
secondariamente, secondly
in terzo luogo, thirdly
a vicenda, in turns
successivamente, successively
a uno a uno, one by one
a due a due, two by two
alla rinfusa, in confusion
etc., etc.

Adverbs of Affirmation

sì, yes
già (dgee-àh), quite so
certo, certainly
certo certo, most certainly
senza dùbbio, without doubt
senza fallo, without fail
infatti, indeed
davvero, in truth, etc.

Adverbs of Negation

no, no
non, not
neanche, not even
niente affatto, not at all
mai (pron. màh-ee), never
ma che, certainly not, etc.

Adverbs of Doubt

forse, perhaps
probabilmente, probably
potrebbe darsi, it may be
chi sa se, who knows if
è possibile, it is possible
caso mai, if by any chance
etc., etc.

EXERCISE XLVII.

1. Venga di qua, signore; la strada è molto più breve. 2. Vuol dunque ch' io sia costretta di domandàr qua e là cosa sia accaduto al mio padrone?

3. Uno dopo l'altro tutti si allontanàrono e mi lasciàrono solo. 4. Caso mai dovesse venire quel signore di ieri, ditegli che non sono in casa. 5. Chi sa se arriveremo in tempo. 6. Non promettete mai se non siete affatto sicuri di potèr mantenère la vostra promessa. 7. Avete giocato abbastanza, ora è tempo di andare a letto. 8. È possibile che c' incontreremo a Milano in aprile o maggio. 9. Se camminiamo così lentamente non saremo lassù nemmeno per domani. 10. Venite giù; la carrozza è pronta.

CONVERSAZIONE

Quando possiamo vederci per parlare del nostro affare?

Veramente in questo momento sono molto occupato, ma se vuol venire da me domani, prima di mezzogiorno, mi troverà certamente.

Benìssimo, sarò da lei domani verso le ùndici.

Che cosa ha risposto all'avvocato?

Ho risposto chiaro e netto che non intendo pagare.

Quel giovanotto veste molto semplicemente, non è vero?

Sì, ed è sempre molto elegante.

Se avete bisogno di danaro, ditemelo francamente.

Gràzie, ne ho abbastanza.

Da quanto tempo non vede la signorina di cui mi parlò tanto bene?

La vidi un mese fa in casa Raffi.

Andate spesso in città?

Prima ci andavo ogni settimana, ma ora sono obbligato di andarci molto più spesso.

IRREGULAR VERBS—continued

Remarks. Before the terminations of the past definite (*-si, -se, -sero*) and of the past participle (*-so, -to, -sto*) the final consonants of the stem undergo many and different phonetic changes. It has already been seen [page 4792] that the verbs with the stem in *d, nd, n* drop these consonants before the terminations *-si, -so, -sto*. Other important changes of the stems are:

1. In the verbs with the stem ending in *c, g, t, r*, preceded by a vowel, these letters are assimilated with the following *s, t*, which are therefore doubled. Examples:

Cuòcere (to cook), *past def. cossi, past part. cotto.*

Distruggere (to destroy), *past def. distrussi, past part. distrutto.*

Scuotere (to shake), *past def. scossi, past part. scosso.*

Muovere (to move), *past def. mossi, past part. mosso.*

2. The verbs with the stem in *c, g, r*, preceded by a consonant, drop these consonants. Examples:

Vincere (to win), *past def. vinsi, past part. vinto.*

Dipingere (to paint), *past def. dipinsi, past part. dipinto.*

Risolvere (to resolve), *past def. risolsi, past part. risolto* (better *risoluto*).

The same may be said of the verbs having *gu* in the stem. Examples:

Distinguere (to distinguish), *past def. distinsi, past par. distinto.*

3. The verbs with the stem in *rr, ll, gl*, drop the first consonant before the terminations. Examples:

Correre (to run), *past def. corsi, past part. corso.*

Svellere (to root up), *past def. svelsi, past part. svèlto.*

Scegliere (to choose), *past def. scelsi, past part. scelto.*

4. The verbs with the stem ending in *m* change the *m* into *ss* before the terminations. Examples:

Esprimere (to express), *past def. espressi, past part. espresso.*

5. The compounds of *sumere* change the *m* into *n*. Example:

Presumere (to presume), *past def. presunsi, past part. presunto.*

6. Some verbs have two forms of the past participle, regular and irregular. Example:

Aprire (to open), *past def. aprii* and *apersi.*

7. Some have a double participle. Example:

Seppellire (to bury), *past part. seppellito* and *sepolto.*

8. Of the verbs in *i* (which have been already mentioned), some change the vowel of the stem, and these generally take the original vowel of the Latin. Examples:

Fare (to do), *past def. feci.*

Vedere (to see), *past def. vidi.*

9. Also some verbs in *-si* change the vowel of the stem. Examples:

Espellere (to expel), *past def. espulsi, past part. espulso.*

10. Some double the consonant. Example:

Tenere (to hold), *past def. tenni.*

11. Some double the consonant and change the vowel at the same time. Example:

Rompere (to break), *past def. ruppi.*

12. Some end in the past def. in *ui*. Example:

Nascere (to be born), *past def. nacqui.*

Note the *past def.* in *ri* of *parère* (to seem) and *apparire* (to appear), *parvi, apparvi;* and in *bbi* of *conòscere* (to know), and *crèscere* (to grow), *conobbi* and *crebbi*. [See page 4647.]

Second Conjugation—continued

Verbs in **ere** (short)—continued

Accorgere (*-si*), to perceive

Past Def.—Accòrsi, accòrse, accòrsero.

Past Part.—Accòrto.

Addurre (*addùcere*), to adduce, to convey

Ind. Pres.—Adduco, adduci, etc.

Imperf.—Adducevo, adducevi, etc.

Past. Def.—Addussi, adducesti, addusse, adducemmo, adduceste, addùssero.

Future—Addurrò, addurrai, etc.

Subj. Pres.—Adduca, etc.

Subj. Imperf.—Adducessi, etc.

Condit.—Addurrei, addurresti, etc.

Gerund—Adducendo.

Past Part.—Addotto.

Affliggere, to afflict

Past Def.—Afflissi, afflisse, afflissero.

Past Part.—Afflitto.

Aspergere, to sprinkle

Past Def.—Aspersi, asperse, aspèrsero.

Past Part.—Asperso.

Assolvere, to absolve

Past. Def.—Assolvetti (regular), *assolsi, assolse, assòlsero.*

Past Part.—Assoluto and *assolto.*

Assumere, to assume

Past Def.—Assunsi, assunse, assùnsero.

Past Part.—Assunto.

Cingere, to gird

Past. Def.—Cinsi, cinse, cinsero.

Past Part.—Cinto.

Cogliere, to gather

Ind. Pres.—Colgo, cogli, còglie, cogliamo, cogliete, còlgono.

Past Def.—Colsi, colse, còlsero.
Subj. Pres.—Colga, colga, colga, cogliamo, cogliate, còlgano.
Past Part.—Còlto.
Conjugate like *cògliere*: *accògliere*, to welcome; *raccògliere*, to collect.

Comprimere, to compress
Past Def.—Compressi, compresse, comprèssero.
Past Part.—Compresso.

Condurre (*condùcere*), to lead [see *addùrre*].

Connettere, to connect
Past Def.—Connettei (regular), and *connessi, connesse, connèssero.*
Past Part.—Connesso.

Correre, to run
Past Def.—Corsi, corse, córsero.
Past Part.—Córso.
Conjugate like *còrrere*:
concòrrere, to concur — *rincòrrere*, to pursue
incòrrere, to incur — *ricòrrere*, to recur, to have recourse
occòrrere, to occur — *percòrrere*, to peruse
accòrrere, to run up — *decòrrere*, to elapse

Cuocere, to cook (pron. koo-ò-chehreh)
Ind. Pres.—Cuòcio, cuoci, cuoce, cociamo, cocete, cuòciono.
Past Def.—Cossi, cosse, còssero.
Subj. Pres.—Cuòcia, etc.: *cociamo, cociate, cuóciano.*
Past Part.—Cotto.

Deprimere, to depress [see *comprìmere*]
Desumere, to infer [see *assùmere*]

Depingere, to paint
Past Def.—Dipinsi, dipinse, dipìnsero.
Past Part.—Dipinto.

Dirigere, to direct
Past Def.—Diressi, diresse, dirèssero.
Past Part.—Diretto.

Discutere, to discuss
Past Def.—Discussi, discusse, discùssero.
Past Part.—Discusso.

Dissolvere, to dissolve
Past Def.—Dissolvetti or *dissolvei* (regular), and *dissolsi, dissolse, dissòlsero.*
Past Part.—Dissoluto.

Distinguere, to distinguish
Past Def.—Distinsi, distinse, distìnsero.
Past Part.—Distinto.

Distruggere, to destroy
Past Def.—Distrussi, distrusse, distrùssero.
Past Part.—Distrutto.

CONVERSAZIONE.

Qual'è la via più corta per andare a . . . ?
Prenda la prima strada qui a destra, e vaa sempre diritto.
È lontano ?
Non molto. Camminando di buon passo, ci vorrà un venti minuti.
A che ora ritornerà ?
Prestìssimo, per le ùndici e mezzo al più tardi devo èssere in casa.
Ecco un ufficio postale. voglio comprare dei francobolli (stamps).
Due francobolli da dieci centèsimi (1d.) e uno da venticinque (2½d.), per piacere.
Dove posso comprare della carta da lèttere ?
Dal libràio qui vicino.
Gràzie, signore ; le sono molto obligato.

EXERCISE XLVIII.

1. Le ragioni che avete addotte non giustìficano il vostro operato. 2. La volta di questa chiesa fu dipinta da un grande artista. 3. Il fuoco distrusse una gran parte del fabbricato. 4. Quando esse si accòrsero della mia presenza, cominciàrono a parlàr d' altro. 5. Ho corso tutto il giorno, ora ho bisogno di un po' di riposo. 6. Non posso mangiare questa carne; è troppo cotta. 7. Si è già molto discusso su questo soggetto. 8. Venne giù una nèbbia così fitta, che non si poteva distinguere niente. 9. I nemici dirèssero il fuoco contro il forte B. 10. Ecco quanto abbiamo potuto raccògliere.

KEY TO EXERCISE XLV.

1. The poor child has been bitten by a dog. 2. Boys, where have you hidden this gentleman's hat ? 3. We have played, and, as usual, we have lost. 4. Who has taken my penknife ? 5. I am surprised at your behaviour. 6. We were surprised from behind, and were obliged to surrender. 7. I am surprised that you have not yet answered (to) my letter. 8 I have spent more than I should have done. 9. The works have been suspended until further orders. 10. Have you heard Puccini's new opera ? 11. I have given you two months' pay. I do not know what you claim more.

Continued

FRENCH

Continued from page 4940

By Louis A. Barbé, B.A.

THE ADVERB

Adverbs (*les adverbes*) may be either (a) single and simple words—that is, words not formed from others by the addition of a suffix : (b) single words derived from adjectives by the addition of a suffix ; or (c) expressions made up of several words. In this last case they are called adverbial phrases (*locutions adverbiales*).

With regard to their meaning, adverbs may be divided into adverbs of (1) time, (2) place, (3) quantity, (4) affirmation, (5) negation, and (6) manner.

The chief of these will be found in the following lists :

1. Adverbs of Time

alors, then
après, after
après-demain, the day after to-morrow
aujourd'hui, to-day
autrefois, formerly
aussitôt, immediately
auparavant, before
avant-hier, the day before yesterday
bientôt, soon
cependant, meanwhile
déjà, already
demain, to-morrow
depuis, since
désormais, henceforth
dorénavant, henceforward
encore, again, yet, still
enfin, at last
ensuite, afterwards
hier, yesterday
jadis, formerly
jamais, ever, never
longtemps, long
maintenant, now
parfois, at times
puis, then
quand, when
quelquefois, sometimes
souvent, often
tard, late
tantôt, by and by, a short time ago
tôt, early
toujours, always, still

Other expressions of time are:

la veille, the day before	*le lendemain,* next day
l'avant-veille, two days before	*le surlendemain,* two days after
le lendemain matin (soir) next morning (evening)	*la veille au matin (soir)* the morning (evening) before

Tard cannot be used as an adjective. "You are late" is "*Vous êtes en retard.*"

2. Adverbs of Place

ailleurs, elsewhere	*devant,* before, ahead
alentour, around	*ici,* here
auprès, near	*là,* there
dedans, inside	*loin,* far
dehors, outside	*où,* where
dessus, above	*d'où,* whence
dessous, below	*partout,* everywhere
derrière, behind	*partout où,* wherever

y, there.

Y is a pronoun when it means not "there" but "to it," "to them," etc. In any case, however, its place in the sentence is always that of a conjunctive pronoun.

"There" is to be translated by *y,* not by *là,* when it refers to a place mentioned before. After "it is," etc., *là* is to be used.

3. Adverbs of Quantity

assez, enough	*guère,* but little
autant, as much	*moins,* less
beaucoup, much, many	*peu,* little, few
bien, much, many	*plus,* more
combien, how much	*trop,* too much
davantage, more	*que,* how! how much! how many!

When these adverbs are used in connection with a noun, the preposition *de* is always required between the adverb and the noun: *Il a beaucoup de livres,* He has many books.

Bien is the only one that takes the definite article as well as *de*: *Il a bien des livres,* He has many books.

When the noun is understood, and replaced by a pronoun, that pronoun must be *en*: *A-t-il beaucoup de livres? Oui, il en a beaucoup,* Has he many books? Yes, he has many.

Assez (enough) may never come after the noun, as it sometimes does in English: *Avez-vous assez d'argent?* Have you money enough?

Davantage (more) is never followed by either *que* or *de.* Its place is at the end of a sentence. It may be preceded by *en* (before the verb) like any other adverb of quantity: *Il a assez d'argent; ne lui en donnez pas davantage,* He has enough money; do not give him any more.

Beaucoup must never be preceded by any other adverb. If a stronger expression be required, some other word must be used, such as *infiniment, excessivement,* etc.

4. Adverbs of Affirmation, Negation, and Doubt

oui, yes	*non,* no
si, yes	*ne,* not
certes, certainly	*pas,* not
même, even	*point,* not
cependant, however	*guère,* little

peut-être, perhaps

Oui is the ordinary affirmative adverb. *Si* is used either by way of contradiction or in answer to a question put negatively. It is frequently preceded by *mais,* which makes it more emphatic. It may also be emphasised by placing *fait* after it. The English equivalent of *si* is commonly "yes" plus an auxiliary: *Est-ce que vous n'allez pas à Paris? Si.* Are you **not** going to Paris? Yes, I am.

Even in French, *si* is very frequently followed by the verb used in the previous statement or question: *N'avez-vous pas lu ce roman? Si, je l'ai lu,* Have you not read this novel? Yes, I have read it.

Owing to its contradictory force, *si* is hardly a polite expression, and, except in familiar conversation, had better be replaced by some other formula, such as: *Je vous demande pardon,* I beg your pardon.

In "indirect speech," *oui* and *si* are preceded by *que*: *Pleut-il? Je crois que oui,* Is it raining? I think so (yes). *Vous dites que non, je dis que si,* You say no, I say yes.

As may be seen from the last example, the same remark applies to *non* (no).

Ne is the only simple negative. Except in certain idiomatic constructions, where its use is pleonastic, it seldom occurs alone. It is used in connection with *pas, point* (which is rather stronger than *pas*), *nul, nullement, ni, aucun, aucunement, guère, jamais, plus, rien, personne*: *Nul n'est prophète en son pays,* No one is a prophet in his own country. *Il n'a aucune envie de partir,* He has no wish to go away. *Personne n'est mécontent de soi,* No one is dissatisfied with himself.

Ne is frequently used without *pas* or *point* in connection with the verbs *cesser,* to cease; *oser,* to dare; *pouvoir,* to be able; and *savoir,* to know: *Cet enfant ne cesse de nous tourmenter,* That child does not cease worrying us. *Il ne peut parler,* He cannot speak. *Je ne sais s'il réussira,* I no not know whether he will succeed. *Je n'ose vous adresser ma demande,* I dare not make my request to you.

A sentence in which *peut-être* occurs admits of three constructions:

(a) *Peut-être* may begin the sentence, and in this case the subject and verb take the same places as in interrogative sentences: *Peut-être ses amis l'ont-ils vu pour la dernière fois,* Perhaps his friends have seen him for the last time. *Peut-être ne voudra-t-il pas nous répondre,* Perhaps he will not wish to answer us.

(b) *Peut-être* may be placed after the verb in a simple tense, or between the auxiliary and the past participle in a compound tense: *Nous lui écrirons peut-être demain,* We shall perhaps write to him to-morrow. *Il ne vous a peut-être pas vu,* Perhaps he has not seen you.

(c) When *peut-être* begins a sentence, it may be followed by *que,* and does not then require any change in the order of the subject and verb: *Peut-être qu'il ne nous a pas compris,* Perhaps he has not understood us.

5. Adverbs of Manner

A few adverbs of manner are simple forms, such as *bien,* well; *mieux,* better; *mal,* badly; *pis,* worse; *ainsi,* thus. The majority of them are derivatives ending in *ment,* and formed from adjectives according to the following rules:

Formation of Adverbs from Adjectives

1. To form adverbs from adjectives ending in a vowel, add *ment*: *facile,* easy; *facilement,* easily; *obstiné,* stubborn; *obstinément,* stubbornly; *poli,* polite; *poliment,* politely; *dû,* due; *dûment,* duly; *éperdu,* distracted; *éperdument,* distractedly. Exceptions:

(a) A circumflex accent is to be placed on the final of the following adverbs ending in *u*: *assidu,* assiduous; *assidûment,* assiduously; *cru,* crude; *crûment,* crudely; *résolu,* resolute; *résolûment,* resolutely; *indu,* undue; *indûment,* unduly.

The adverb formed from *gai* (gay) may be written either *gaîment* or *gaiement.*

(b) The following adjectives ending in *e* must take an acute accent before the additional *ment*: *aveugle,* blind; *aveuglément,* blindly; *commode,* convenient; *commodément,* conveniently; *incommode,* inconvenient; *incommodément,* inconveniently; *énorme,* huge; *enormément,* hugely: *conforme* conformable; *conformément,* conformably; *immense,* immense; *immensément,* immensely; *opiniâtre,* stubborn; *opiniâtrément,* stubbornly; *uniforme,* uniform; *uniformément,* uniformly.

(c) *Traître* (treacherous) and *impuni* (unpunished) have the corresponding adverbs *traîtreusément* (treacherously) and *impunément* (with impunity).

2. To form adverbs from adjectives ending in a consonant, add *ment* to the feminine form: *faux,* false; *faussement,* falsely: *frais,* fresh; *fraîchement,* freshly; *actif,* active; *activement,* actively; *nouveau,* new; *nouvellement,* newly. Exceptions:

The following adjectives take an acute accent on the e of the feminine form preceding the termination *ment*: *commun,* common; *communément,* commonly; *confus,* confuse; *confusément,* confusedly: *diffus,* diffuse; *diffusément,* diffusely; *exprès,* express; *expressément,* expressly; *importun,* importunate; *importunément,* importunately: *inopportun,* inopportune; *inopportunément,* inopportunely; *obscur,* obscure; *obscurément,* obscurely; *opportun,* opportune; *opportunément,* opportunely; *profond,* deep; *profondément,* deeply; *précis,* precise; *précisément,* precisely.

The adverbs corresponding with *gentil* (nice) and *bref* (brief) are *gentiment* and *brièvement.*

3. To form adverbs from adjectives ending in *ant* or *ent,* change *nt* into *m,* and add *ment*: *prudent,* prudent; *prudemment,* prudently; *constant,* constant; *constamment,* constantly. Exceptions:

The adverbs corresponding with *lent* (slow), *présent* (present), and *véhément* (vehement) are *lentement* (slowly), *présentement* (at the present time), and *véhémentement* (vehemently). This last is of rare occurrence.

4. The following adverbs are derived from adjectives either wholly obsolete or seldom used: *grièvement,* grievously; *journellement,* daily; *notamment,* notably; *nuitamment,* by night; *sciemment,* wittingly.

The last syllable but one of adverbs ending in *amment* or *emment* has no nasal sound, but is pronounced like *a*: *prudemment,* pru-da-ment; *constamment,* con-sta-ment.

Position of Adverbs

In French an adverb must never be placed, as it frequently is in English, between the subject and the verb: *Je le vois souvent,* I often see him.

Its position is generally after the verb if the verb is in a simple tense, and between the auxiliary and the past participle if the verb is in a compound tense: *Nous en parlons rarement,* We rarely speak of it. *J'ai bien dormi,* I have slept well.

Many adverbs of time and place, however, and adverbial phrases come after the past participle: *Je lui ai parlé hier,* I spoke to him yesterday. *Nous l'avons envoyé ailleurs,* We sent him elsewhere. *Vous l'avez fait à dessein,* You have done it on purpose.

Exercise XXXVI.

1. Men do not arrive immediately at the knowledge of truth. 2. There is nothing more vexatious (*fâcheux*) than uncertainty (*incertitude,* f.). 3. If we had only lived two centuries earlier, we should have had no idea of steam-engines (*la machine à vapeur*), of railways, of the telegraph (*le télégraphe*). 4. Laziness goes so slowly that poverty soon overtakes (*atteindre*) it. 5. The reason of the strongest is always the best. 6. Young people must speak little and listen much. 7. The happiness of the wicked (sing.) does not last (*durer*) long. 8. That thief is accused of having entered (*s'introduire*) a house by night. 9. Let him come Friday or Saturday; those are the days when I am most usually (*ordinaire*) at home in the evening. 10. And now, answer me frankly, what is there (*de*) true in this accusation? 11. I have always wondered (asked myself) why the French, who are so smart (*spirituel*) at home, are so stupid (*bête*) when travelling (*en voyage*). 12. An extraordinary good fortune (*le bonheur*) has constantly accompanied that brigand (*le brigand*) to (*jusqu'à*) this day. A price is set on his head (his head has been put to price); nevertheless he continues with impunity his dangerous trade (*le métier*). 13. He is extremely generous (*généreux*): money costs (*coûter*) him but little to earn (*gagner*), and he spends (*dépenser*) it easily with the poor. 14. He ordinarily wears (*porter*) a costume (*le costume*) of very great elegance (*élégance,* f.); his linen (*le linge*) is always of dazzling (*éclatant*) whiteness (*la blancheur*).

Key to Exercise XXXV.

Dans une lettre à sa cousine, un écrivain français, Paul-Louis Courier, raconte une aventure terrible qui lui est arrivée en Italie. Il voyageait en Calabre avec un ami. C'est un pays montagneux, et les chevaux des deux voyageurs marchaient avec beaucoup de peine. C'était le camarade de Courier qui allait devant. Il vit un sentier qui lui parut plus practicable et plus court, le prit et les égara. Tant qu'il fit jour ils cherchèrent leur chemin; mais plus ils cherchaient plus ils se perdaient, et il était nuit noire quand ils arrivèrent près d'une maison fort noire. Ils y entrèrent, non sans soupçon, et seulement parce qu'ils ne pouvaient (pas) faire autrement. Là ils trouvent toute une famille de charbonniers à table, où l'on invita aussitôt les deux voyageurs. "Mon jeune homme ne se fit pas prier," dit Courier. "Nous voilà mangeant et buvant, lui, du moins. Car pour moi, j'examinais le lieu et la mine de nos hôtes. Nos hôtes avaient bien mines de charbonniers; mais la maison, vous l'eussiez (auriez) prise pour un arsenal. Ce n'étaient que fusils, pistolets, sabres, couteaux, coutelas." Tout cela lui déplut, et il vit bien qu'il déplaisait aussi. Son camarade, au contraire, était de la famille; il riait, il causait, il dit d'où il venait, où il allait, qui il était. Pour ne rien omettre de ce qui pourrait le perdre, il fit le riche, promit aux charbonniers tout ce qu'ils voulurent pour lui servir de guides le lendemain. Enfin, il parla de sa valise, les pria d'en avoir grand soin et de la mettre au chevet de son lit. Il ne voulait point, disait-il, d'autre traversin. Les charbonniers durent croire qu'il portait les diamants de la couronne. Quand le souper fut fini les hôtes descendirent et laissèrent les voyageurs, qui devaient coucher dans la chambre haute où l'on avait mangé. Le plus jeune des deux se coucha sans la moindre hésitation, la tête sur la précieuse valise. L'autre, déterminé à veiller, fit bon feu, et s'assit auprès. La nuit se passa tranquillement, et il commençait à se rassurer, quand sur (vers) l'heure où il lui semblait que le jour ne pouvait être loin, il entendit qu'on parlait au-dessous de lui. Il écouta. C'était le charbonnier qui disait à sa femme: "Eh bien! Enfin,

voyons, faut-il les tuer tous deux ?" A quoi la femme répondit, "Oui." Le malheureux voyageur resta respirant à peine ; à le voir on n'eût (aurait) su s'il était mort ou vivant. Il n'osait appeler ni faire du bruit ; il ne pouvait s'échapper tout seul. La fenêtre n'était pas bien haute, mais en bas il y avait deux gros dogues qui hurlaient comme des loups. Au bout d'un quart d'heure qui lui sembla bien long, il entendit quelqu'un sur l'escalier, et, par les fentes de la porte, il vit le père, sa lampe dans (à) la main, dans l'autre un de ses grands couteaux. Le charbonnier monta, sa femme après lui. Il ouvrit la porte : mais avant d'entrer il posa la lampe, que sa femme vint prendre ; puis il entre pieds nus, et elle de dehors lui disait à voix basse : "Doucement, va doucement" Quand il fut venu près du lit où était étendu le pauvre jeune homme, offrant sa gorge découverte, d'une main il lève son couteau et de l'autre—il saisit un jambon qui pendait au plafond, en coupe une tranche, et se retire comme il était venu. Dès que le jour parut, toute la famille à grand bruit vint éveiller les voyageurs. On servit un déjeuner fort propre et fort bon. Il consistait de deux chapons, dont il fallait, dit l'hôtesse, emporter l'un et manger l'autre. En les voyant, Courier comprit enfin le sens de ces terribles mots: "Faut il les tuer tous deux."

Continued

SPANISH

Continued from page 4943

By Amalia de Alberti & H. S. Duncan

PREPOSITIONS

Spanish prepositions are simple and compound. Simple prepositions consist of one word placed before the noun—as *de*, of, from. Compound prepositions are prepositional phrases composed of a noun, adjective, or adverb with a preposition, or of two prepositions—as *acerca de*, concerning: *de abajo*, from under.

Simple Prepositions. The simple prepositions are :

á, to	*hasta*, till, until, up to, to
ante, before	*mediante*, through, by means of
bajo, under	*menos*, except
con, with	*no obstante*, notwithstanding
contra, against	*para*, for, in order to, to
de, of, from	*por*, by, through, for
desde, from, since	*salvo*, except, save
durante, during	*segun*, according to
en, in, at, on	*sin*, without
entre, between, among	*sobre*, on, upon, about
excepto, except	*tras*, after
hácia, towards	

Use of á. 1. *á*, to. The primary meaning of *á* is motion towards a certain point. Examples: *Ir á Londres*, to go to London: *Voy á la iglesia*, I am going to church.

2. *á* is also used to express the dative "to," and the "to" standing between a verb and an infinitive. Examples: *Dar á los pobres*, to give to the poor: *Fuí á verla*, I went to see her.

3. *á* must also be used after the verb before a definite *personal* object. Examples: *Leer libros*, to read books: *leer el libro*, to read the book: *ver niños*, to see children; *ver á la niña*, to see the child (f.).

4. In the following senses *á* represents the English "at." Examples: *Estoy á la puerta*, I am at the door: *estan á la mesa*, they are at table: *á las diez de la noche*, at ten o'clock at night; *á diez duros la docena*, at ten dollars a dozen: *al anochecer*, at nightfall; *jugar á los naipes*, to play at cards: *á tres dias vista*, at three days' sight.

5. Certain verbs are always followed by *á*. Examples: *Amar* (*querer*) *á alguien*, to love anyone: *aborrecer á alguien*, to hate anyone: *saber á*, to taste of; *oler á*, to smell of.

6. *á* expresses the English "by" in such phrases as: *Poco á poco*, little by little: *uno á uno*, one by one.

7. *á* is also frequently used to express manner, and in adverbial phrases. Examples: *á la Inglesa*, in the English manner; *á la Turca*, in the Turkish manner; *á mi manera*, in my own way; *á pié*, on foot; *á caballo*, on horseback.

Use of De, of, from, **and Desde,** from. 1. *De* represents all the general uses of "of" and "from" in English; it also shows the possessive case where the apostrophe would be used in English. Examples: *De Londres á Madrid*, from London to Madrid: *una carta de mi hermana*, a letter from my sister; *la casa de mi madre*, my mother's house.

2. It may also represent "to," "with," "at." Examples: *El camino del pueblo*, the way to the village: *temblar de frio*, to tremble with cold; *ofenderse de nada*, to be offended at nothing.

3. It also denotes a state. Examples: *Estoy de luto*, I am in mourning: *Estámos de visitas*, We are paying calls: *ciego de furor*, blind with fury.

4. When "from" signifies a starting-point of time or place, *desde* must be used instead of *de*. Examples: *Desde la tierra hasta la luna*, from the earth to the moon: *desde entonces*, from thenceforth; *desde la mañana hasta la tarde*, from the morning until the evening.

Use of Para and Por. 1. *Para* signifies "for" in the sense of purpose, destination, "for the purpose of," "in order to" generally being implied.

2. "For" is translated *para* when it expresses:

(*a*) The destination of an object or a journey. Examples: *Ese traje es para mí*, That dress is for me; *Lo hizo para Vd*, He did it for you; *Salgo para Londres*, I am starting for London.

(*b*) Duration of anything. Examples: *Tenemos vino para tres años*, We have wine for three years; *Durará para siempre*, It will last for ever.

(*c*) A fixed epoch. Example: *Dejemos eso para mañana*, Let us leave that for to-morrow.

(*d*) The relation between one thing and another. Example: *Es muy pequeño para su edad*, He is very small for his age.

3. When a comparison is intended, *con* must be inserted after *para*. Example: *¡Quien soy yo para con ella!* What am I compared to her!

4. *Para con* also means conduct towards a person. Example: *Su conducta para con su hijo*, His behaviour towards his son.

5. In the following sentences *para* signifies "just on the point of" or "in order." Examples: *Estamos para salir*, We are just going out; *Para enseñar es menester saber*, In order to teach, it is necessary to know.

1. *Por* signifies "for" when it expresses:

(*a*) Length of time. Example: *Me voy por una semana*, I am going away for a week.

(*b*) The price of anything. Example: *Lo venden por tres duros*, They sell it for three dollars.

(*c*) In favour of, instead of. Examples: *Hablaré por Vd*, I will speak for you (in your favour); *Lo haré por Vd*, I will do it for you (instead of you).

(*d*) Exchange. Example: *Dar una cosa por otra*, to exchange one thing for another.

(*e*) With verbs of action or motion. Examples: *Ir por agua y leña*, to go for water and wood; *enviar por el médico*, to send for the doctor.

2. *Por* also signifies "out of," "through," "on account of"—namely, the motive or cause of an action. Examples: *Lo hizo por malicia*, He did it out of spite; *Lo haré por Vd*, I will do it for you (for your sake).

3. *Por* after a verb in the passive voice denotes agency, and is translated "by." Example:

Fué criado por su tio. He was brought up by his uncle.

Prepositional Phrases

ademas de, besides
alrededor de, around, about
antes de, before (anterir)
á la vista de, in sight of
al cabo de, at the end of
al través de, across, through
á pesár de, in spite of
cerca de, near
debajo de, under
delante de, before (in front of)
dentro de, within, into
despues de, after
detrás de, behind
encima de, on
fuera de, outside
lejos de, far from
conforme á, according to
contrario á, contrary to
junto á, near to
respecto á, with respect to
tocante á, touching
á casa de, to the house of
á causa de, because of
á excepcion de, excepting
á fuerza de, by dint of
á razon de, at the rate of
de parte de, on the part of, from
de casa de, from the house of
en frente de, opposite
en lugar de, instead of
en medio de, in the midst of
en vez de, instead of
en vista de, in view of
mas allá de, beyond
por causa de, on account of
por el lado de, on the side of
por razon de, by reason of
sin embargo de, notwithstanding
juntamente con, together with
en cuanto á, with respect to, as to
por entre, between
por encima de, over
por detrás de, behind

EXERCISE XX (1).

Translate into Spanish:

1. At the dinner hour, before the soup, under pretext that the table was not well laid, he gave the lamp a knock with his hand, and overturned it. 2. During a thunderstorm fear made her faint. 3. According to what they tell me, without doubt Mr. A. leaves to-morrow. 4. In spite of having no friendship for her, I went to see her. 5. He came to see me at ten o'clock at night, and offered me those knives at ten dollars the dozen. 6. We will drive out in a carriage at nightfall. 7. I love that woman; I am fond of her dog, and hate her family. 8. This water tastes of earth. 9. Little by little, they left, one by one. 10. How do you like coffee, in the Turkish or the French manner? 11. How did you go into the country—on foot? I went on horseback. 12. Can you dine with me to-morrow? No, I leave to-morrow morning for Paris. 13. Besides this purse, he gave me this silver pencil. 14. There is shade under the trees, and it is a good thing they are in front of the house. 15. There is exquisite furniture in the house, and it is sad to think that after so many years it is to be sold; the sale will take place on the lawn behind the house. 16. She carries over her shoulders a shawl worth a fortune. 17. His ignorance is in sight of all.

EXERCISE XX. (2)

Translate the following into English:

1. Al cabo de veinte años, cuando lo creíamos muerto: volvió á casa. 2. En vez de venir el mismo mandó su delegado. 3. Por razon de su desventura le perdonó su ofensa. 4. En cuanto á lo que Vd me dijo he venido á saber que no es verdad. 5. Por encima de las montañas cayó el agua en forma de catarátas, destruyendo todo, y la muerte sorprendió á esa pobre gente en medio de su alegría. 6. Mas allá del camino real encontrará la vereda que conduce á la fuente. 7. Sin embargo de haberlo dicho que no volviera mas, vino esta mañana. 8. Salió de casa de su padre para no volver mas. 9. Me trajo una carta de parte de mi abogado; el pleito va mal.

Commercial Phraseology	Fraseologia Commercial
I beg you will return me this document after perusal	Le ruego se sirva devolverme este documento despues de repasado
To be responsible for a payment	Contraer la responsabilidad de un pago
We effect sales and guarantee the payment, charging you ½ per cent. per month	Efectuamos ventas, y garantizamos el pago, cargandole ½ % mensual
The different copies forming a set	Los diferentes ejemplares que forman un juego
At sight, sixty, ninety days' sight	Á la vista, sesenta, noventa dias vista (d/v)
To the order of Messrs. . . . or ourselves	A la orden de los Sres. . . . . ó de nosotros mismos
The sum of . . . , at the exchange of . .	La suma de . . . , al cambio de . . . .
To force a person to keep the contract	Forzar á una persona á que cumpla su contrato
To cancel, or annul a contract	Cancelar ó anular un contrato
A contract in force	Un contrato vigente
An expired contract	Un contrato caducado
Smuggled goods	Mercancias de contrabando
The promissory note	El pagaré
The import list	La lista de importaciones
The market opened very firm	El mercado abrió muy firme
The market is slack	El mercado está flojisimo
The market clos unchanged	El mercado ciérra sin variacion
Prices are high	Los precios estan altos ó elevados
Prices are improvin	Los precios estan mejorando
Prices have a downward tendency	Los precios tienden á la baja
We are enabled to report a slight improvement in the prices	Podemos anunciar una ligera mejora en los precios
There is hardly anything doing for the moment	Casí es nada lo que se hace por el momento
The market offers nothing of a striking nature	El mercado no ofrece nada nuevo
A falling market	Un mercado en baja
A letter of advice	Una carta de aviso
The share	La accion
The Post Office	La Administracion de Correos
The almanac	El almanaque
The shipowner	El armador
The arrivals	Los arribos
The wine vaults	Las bodegas
The Stock Exchange	La Bolsa

The blot	El borrón
The rough proof	El borrador
We quote cocoa from 70s. to 80s.	Cotizamos el cacao do 70s. á 80s.
It is difficult to make correct quotations	Se hace dificil cotizar atinadamente
The quotation for coffee is merely nominal	La cotizacion de café es puoramente nominal
No business of note has been effected	No se han efectuado ningunos negocios dignos de reseñarse
The buyers are already stocked	Los compradores se hallan ya abastecidos
A general desire has prevailed to effect sales	La tendencia general ha sido á efectuar ventas
In cotton, a good many transactions have taken place	Se han llevado á cabo muchas operaciónes en algodon
The demand has diminished	La demanda ha disminuido
The safe, the strong-box	La caja de hierro
The cashier	El cajero
Copper (money)	Calderílla (f.)
The desk	El escritorio
The pigeon-holes	Los casilleros
To register	Certificar
The consignments	Las consignaciones
The bill of lading	El conocimiento de embarque
A circular	Una circular
Credit	Crédito (m.)
To copy	Copiar
A broker	Un corredor
A correspondent	Un corresponsal
Specie	Efectivo (m.)
To write	Escribir
The book-case	El estante de libros
The invoice	La factura
The date	La fecha
The freight	El flete
The signature	La firma, rúbrica
The draft	El giro
The eraser	La goma de borrar
The balance-sheet	El hoja de balance
Goods	Mercancias (f.)
Current money	Moneda corriente
The counter	El mostrador
The samples	Las muestras
The office	La oficina, el despacho
The writing-paper	El papel de cartas
The blotting-paper	El papel secante
The sealing-wax	El lacre
The penholder	El palillero
Hard cash	Pago al contado
Private	Partícular
The parchment	El pergamino
Weight	Peso (m.)
The pen	La pluma
A steel pen	Una pluma de acero
The postscript	La posdata (f.)
The copying-machine	La prensa de copiar
To borrow	Pedir prestado
The receipt	El recibo (m.)
The claim	La reclamacion
The ruler	La regla
The envelope	El sobre
To underline	Subrayar
The public sales	Las subastas
The copying-ink	La tinta de copíar
A note	Un volante

Key to Exercise XIX. (1)

1. Es cierto que su conducta dió prueba de valor. Ciertamente que nadie lo hubiera creido. 2. Orgullosamente rehusó la recompensa que le fué ofrecida: en este caso su orgullo fué justo. 3. Muy contento se quedó con el regalo que le hicieron. ¿ Quedó contento ? Contentisimo. 4. Muchisima gente acudió para ver la procesion. (No se sirve del superlativo, sera suficiente decir que mucha gente acudió.) 5. Siempre fué perezoso, y jamás se corregirá de ese defecto. ¡ No perdamos la esperanza ; quizás con la edad se corrija ! Tal vez sea asi, pero temo que no. 6. Dió prueba de ser prudente al retirarse de la contienda. Yo diria que prudentemente se retiró, pues su desventaja era clara. 7. ¡ No niego que es cortés, pero no es persona grata, y quisiera cortésmente decirle, adios ! 8. Recientemente murió nuestra amiga, y tambien el recien nacido.

Key to Exercise XIX. (2)

1. Happy is he who lives a tranquil life without great events ; there are many to whom this happens. 2. Hardly had he inherited a large fortune, than he squandered it. 3. Probably the public will sing our praises when it learns what we have done, without understanding the motives which impelled us. 4. Our friend retires early, and rises late. 5. Up and down, in and out, here and there, without ceasing all day, until we got tired of seeing him and closed the door, and I fear he will never forgive us the affront. 6. He discoursed to us learnedly, explaining various subjects, very cleverly expounded, but extremely tedious. 7. He gave more or less all he possessed to the poor, and that was very little; I should willingly have added something, but feared to offend him. 8. The room was filled with smoke, and I blindly sought for the door. 9. The moment that I saw him I knew him, and I immediately spoke to him.

Continued

ESPERANTO

Continued fro page 4944

By Harald Clegg

*Anstataŭ**, instead of.

Example: *Li sidis sur la herbo, anstataŭ labori*, He sat on the grass instead of working.

*Antaŭ ol**, before (time).

Example: *Ŝi forkuris, antaŭ ol mi vidis ŝin*, She ran away before I saw her.

* Any verb immediately following these words is always in the infinitive mood.

Aŭ, or.

Example: *Mi devas iri, aŭ mi alvenos malfrue*, I must go, or I shall arrive late.

Ĉar, for, because, since.

Example: *Mi devas obei, ĉar vi ordonas min*, I must obey, since you order me.

Dum, during, while.

Example: *Li restis silente dum la pastro parolis*, He re-

mained silent while the priest spoke.

Ĝis, until, up to, as far as.

Example: *Li daŭris kanti, ĝis mi foriris*, He continued to sing until I went away.

Ke, that.

Example: *Li kredas, ke mi estas riĉa*, He believes that I am rich.

Kvankam, although.

Example: *Mi renkontos vin, kvankam mi ne deziras vidi vin*, I shall meet you, although I do not desire to see you.

Nek, neither.

Example: *Mi nek movos, nek parolos unu vorton*, I shall not stir, or speak a word.

Se, if.

Example: *Li dankos vin, se vi donos ĝin al li*, He will thank you if you give it to him.

Sed, but.

Example; *Vi trompis min, sed mi vin pardonas*, You deceived me, but I forgive you.

Tamen, however, nevertheless.

Example: *Vi parolas tre malklare, tamen mi vin komprenas*, You speak very indistinctly; nevertheless I understand you.

From many of the root-words given in the vocabularies, adverbial conjunctions may be formed such as *alie*, otherwise; *cetere*, for the rest; *nome*, that is to say: and for this reason such words are not included in the above list of conjunctions.

INTERROGATION

To form an interrogative sentence in Esperanto, *ĉu* is placed at the beginning. This word performs the same offices as the English do, does, did; and in adding *ĉu* no change takes place in an affirmative or negative Esperanto sentence. Examples:

Via frato kantis, Your brother sang. *Ĉu via frato kantis?* Did your brother sing? *La viro ne kuris*, The man did not run. *Ĉu la viro ne kuris?* Did not the man run?

Ĉu is also used to form indirect questions; in such cases representing "whether."

Example: *La reĝo scias, ĉu li estas prava aŭ malprava*, The king knows whether he is right or wrong.

In this connection, careful distinction must be made between English "if" and "whether," as the former is often applied in phrases containing indirect questions. *Se* (if) is purely a conjunction of supposition, or of condition. Examples:

Mi iros se vi konsentas, I will go if you consent. *Mi ne scias ĉu vi konsentas*, I do not know if you agree.

A sentence may contain a direct and an indirect interrogation, in which case *ĉu* is used in both places. Example:

Ĉu vi scias ĉu li venos? Do you know whether he will come?

VOCABULARY

- *arĝent'*, silver
- *bot'*, boot
- *daŭr'*, endure, last
- *dir'*, say, tell
- *donac'*, (to) present
- *esper'*, hope
- *flu'*, flow
- *fum'*, smoke
- *humil'*, humble
- *humor'*, humour, temper
- *instru'*, instruct
- *invit'*, invite
- *kalkul'*, calculate, count
- *kaŭz'*, cause, reason
- *kolor'*, colour
- *kompren'*, understand
- *konklud'* conclude
- *kontent'*, content
- *konvink'*, convince
- *korespond'*, correspond
- *kuraĝ'*, courage
- *larg'*, broad
- *lecion'*, lesson
- *long'*, long
- *manier'*, manner
- *mar'*, sea
- *mez'*, middle
- *modest'*, modest
- *mon'*, money
- *mort'*, die
- *mult'*, much, many
- *najbar'*, neighbour
- *natur'*, nature
- *nebul'*, fog
- *neces'*, necessary
- *neĝ'*, snow
- *nepr'*, unfailingly
- *nigr'*, black
- *nov'*, new
- *nub'*, cloud
- *okup'*, occupy
- *ond'*, wave
- *or'*, gold
- *orel'*, ear
- *parker'*, thoroughly, by heart
- *pen'*, try, endeavour
- *ricev'*, receive
- *varm'*, warm
- *vesper'*, evening
- *veter'*, weather

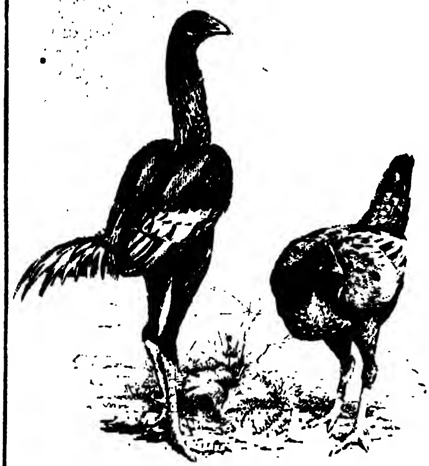
Exercise VII.

During the foggy weather and the cold winter days I remain at home and learn lessons on Esperanto. I can reckon from one to a hundred thousand without difficulty. As time is short, however, and I have much to do, I will endeavour to convince you to-morrow if you agree. Do you wish to correspond with me? The clouds are very black, a cold wind blows, but I hope that we shall not see snow to-day. We hear by our ears and see with our eyes. Although he received many gifts, he was very discontented. He is very rich, but he is nevertheless naturally humble and modest. Our neighbour is very conceited and cowardly. The lesson was short, and the boys learned it by heart. As the wind blew lightly, the waves on the sea were small, and I was not ill. Did he not tell you that he intends to occupy himself with Esperanto? Gold and silver are very necessary. The soldiers' boots are narrow, but they are long. The river flows through broad fields to the sea. Our new neighbour died in the middle of the night. His manner was very strange, but before dying he tried to convince me that he had (has) much gold and silver. Did he not tell you that he would (will) pay you without fail to-morrow?

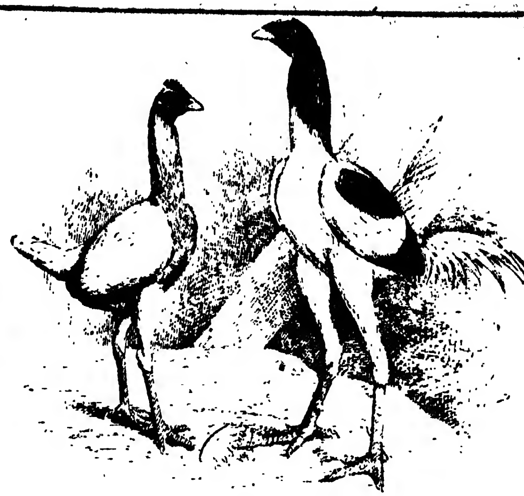
Key to Exercise VI.

En frua mateno la aero estas tre freŝa. La glavo estas akra, kaj facile tranĉas. Mi havas du manojn kaj dek fingrojn. Unue mi deziras diri la veron, kaj due mi volas esti agrabla. En la kampo, ĉe la dekstra flanko, staras du maljunaj arboj. Morgaŭ ni intencas veturi al Londono en la kaleŝo. Futo havas dek du colojn. Vi ne devas forgesi lerni Ekzercon sesan. La infano dolĉe dormas sub la hela lumo de la luno. Li legis la dekan volumon unue. La juna soldato estas malsaĝa kaj mallerta. Mia fidela hundo atendos min, kaj mi ne forgesos doni viandon al ĝi. Ili faris grandan eraron, kaj kaŝis la belan juvelon. Viaj junaj amikoj estas tre kapablaj. Mia eraro ne estas tre grava, kaj mi ne volas vin trompi. Tridek ok kaj dudek sep faras sesdek kvin. Semajno havas sep tagojn. La unua estas dimanĉo, la kvara estas merkredo, kaj laste venas sabato. Ili restos hejme dum la tago. Morgaŭ matene mi atendos vian alvenon je la naŭa horo. La lerta kaj kapabla knabo staras en la unua vico. Lia celo estis trompi la reĝon, forpeli liajn soldatojn, kaj kaŝi

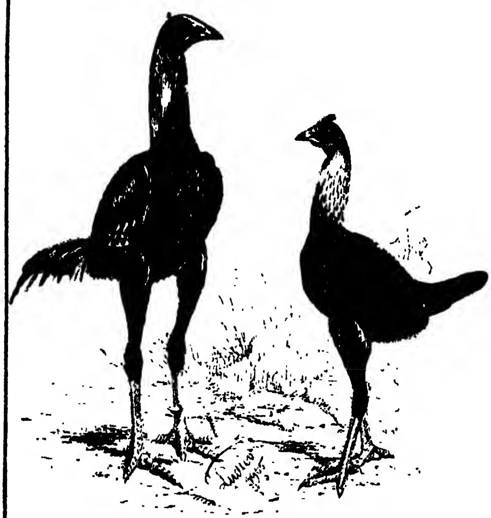
Continued



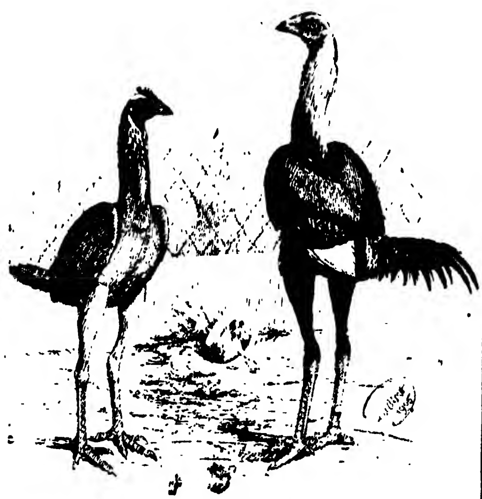
36. SPANGLED



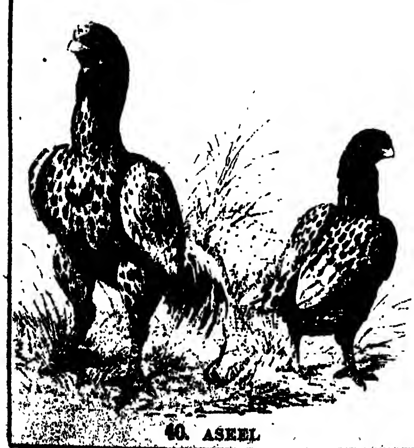
37. PILE



38. BROWN RED



39. DUCKWING

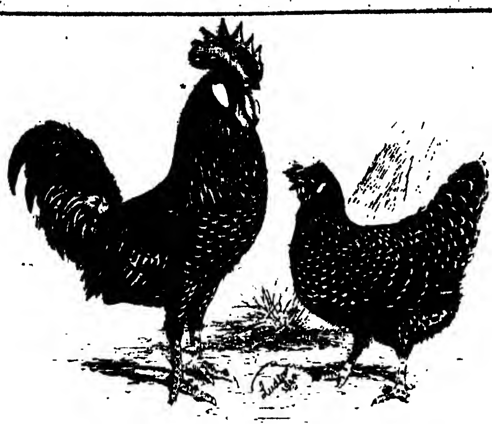


40. ASEEL

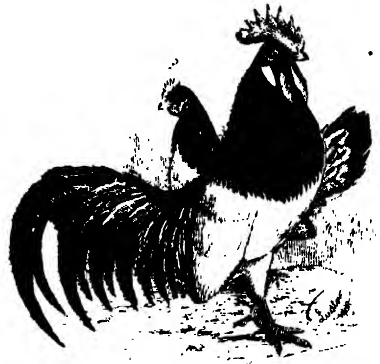
41. OLD ENGLISH

TYPES OF GAME FOWL

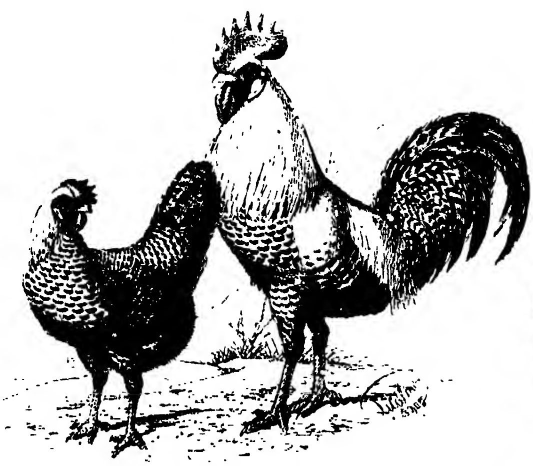
[see AGRICULTURE]



42. ANCONAS

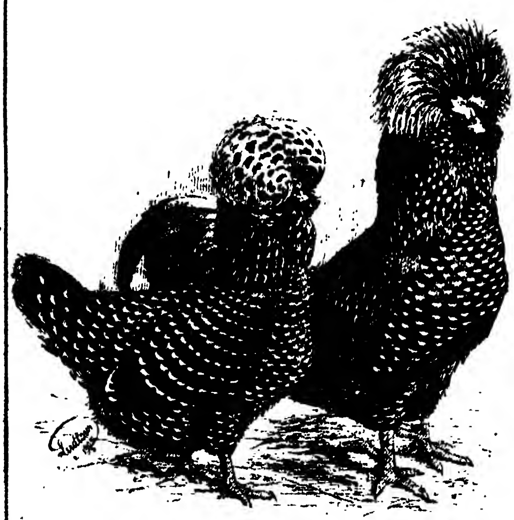


43. LAKENVELDERS

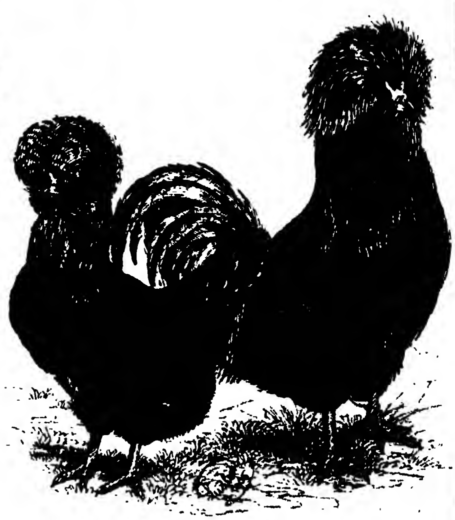


44. CAMPINES

45. FAVEROLLES



46. HOUDANS



47. CRÈVECŒURS

TYPES OF POULTRY

(see AGRICULTURE)

continued from page 4958

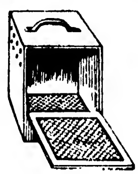
REARING & FEEDING POULTRY

Selecting Eggs for Sitting Hens. Care of the Young Chickens. Hencoops and Chicken-runs. Rations for Chickens and Hens

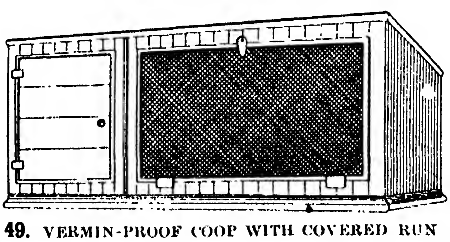
By Professor JAMES LONG

To obtain healthy and strong chickens it is necessary to set the largest and best formed eggs laid by the healthiest hens. The breeding year begins with January, when adult hens lay but few eggs. If the eggs of pullets are used, they should be carefully chosen from the largest and strongest birds, the first ten eggs laid being set aside. As more trouble is involved in midwinter, the greatest care should be exercised in the selection of the hens, as well as of the eggs they lay. As an egg is produced, it should be gathered and laid in bran for protection against frost and damage. As sitting hens are not too common at this early period, the incubator is often employed, but in its absence a nest may be made in a sheltered shed or outhouse, into which vermin cannot enter, and where the hen will remain in comfort, and be able to feed daily. The nest-box [48] may be 16 in. by 18 in. by 18 in., without a bottom, and with a lid hinged to fall down in front. If necessary, a wire run which will confine the bird, may be placed in front, that she may leave her nest and feed and drink at will. Such a box and run will be suitable for outside work in milder weather [49]. If vermin are prevalent, wire netting may be laid beneath both box and run.

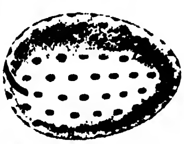
Making the Nest. A nest is made by filling the bottom of the box with fine soil, especially in the angles or corners, and scooping out the centre. Upon this may be laid oat-straw cut in 12 in. lengths, the corners again being filled to prevent the hen pushing or dragging the eggs from the centre and leaving them where she cannot move them back. The best sitters are those containing Dorking or Asiatic blood; Orpingtons, Rocks, and Wyandottes are all useful. Before a hen is placed upon her eggs—and a few dummies [50] should be used until she has settled in her new quarters—a little insect powder may be dusted, or paraffin rubbed under the thighs and wings to prevent vermin disturbing her. A hen which is troubled with insect parasites will often forsake her eggs. Before sitting, each egg should be marked in ink on the small end with figures or letters, that its age and parentage may be recognised for subsequent recording. At the end of three or four days—earlier in the hands of an expert—the eggs may be examined before a candle or the sun, that those which are clear or unfertile may be removed, and used for the chickens or in the kitchen, as they are perfectly good, and the nest made up, if necessary. The infertile egg resembles the new-laid egg in its opacity, while the fertile, like the addled egg, is dark, the former growing darker, and showing a sharper line below the air space at the large end. If two or more hens are set together, the removal of the clear eggs will enable the breeder to make up the sitting—thirteen being the usual number of eggs forming the nest—so that one or more hens may be supplied with fresh lots. Success in hatching chiefly depends upon heat, which the hen supplies; moisture, which prevents the membrane within adhering to the shell or the embryo, and air.



48. SITTING NEST-BOX



49. VERMIN-PROOF COOP WITH COVERED RUN



50. DUMMY EGG

A Special Sitting-house. Where large numbers of chickens are hatched, a special sitting-house [56] may be employed, and the nest-boxes constructed in rows, one row above the other. If the house is large enough, one set built on two or three sides of the floor of the apartment may be sufficient. In such a case, the lids are better at the top, and in all cases there should be ventilating holes, unless the lid is *slatted*. In such a house, which must be well ventilated, a few metal show cages should be provided, in which water and food are placed each morning. As each hen is removed from her nest, she is placed in a cage and allowed to feed for 15 to 30 minutes before replacing. She should be gently lifted under the wings, both flights and legs being grasped. While feeding, the nests should be examined, either for testing the eggs or for removing those which are cracked or broken, if any, or cleaning those which are soiled, and at the same time removing the soiled straw. At night the house may be entered, to ascertain by listening whether any hens are uneasy from the attacks of insects. Every nest-box should be well lime-washed, and insect powder may be dusted over the straw. Lime should follow the removal of a hen, or precede the introduction of a successor.

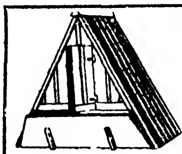
How to Test the Eggs. When the hatching day arrives, the eggs may be examined at the usual hour, unless the chickens have left the shell. No attempt should be made to remove the chicken from the shell by force. Such practice is usually fatal. In some cases, the eggs may be sprinkled with warm water the day before hatching. If they are abnormally dry, the steaming which follows on the return of the hen will assist the chickens to emerge. Eggs which have not hatched, if examined before a light, will often be recognised, by the dull line below the air chamber, as addled, or that the chickens within are dead. If, however, such eggs are placed in a bowl of warm water, about 90° F., further information may be gained. Those living will usually float, and the eggs will move, while those which are worthless may sink. Eggs which are not chipped within 24 hours after hatching is due may be broken at the large end, and examined, when the chick will usually be found dead. Death in the shell may be owing to want of moisture, strength, or vitality.

51 DRINKING FOUNTAIN

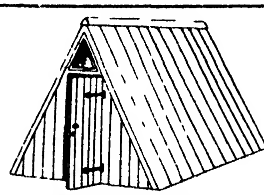
Removal to the Coop. The hen and her chickens may be removed, when hatching is complete, to a coop, placed in winter in a sheltered apartment, or in spring and summer on a dry path or plot out of doors, the hen being then well fed. Her chickens, supplied by Nature with the yolk of the egg, really need no food for 18 to 24 hours. It is now important to protect the young birds, although not to coddle them, and to keep them clean and healthy. They must be kept free from insect parasites, and never allowed to drink or feed upon tainted food or water. The coop should never be placed where either chickens or poultry of any kind have, in the same or the previous year, been running. A pure, dry soil is one of the essentials. In winter, an outhouse, open to the sun and air, the floor being well and thickly sanded, or covered with dry earth, is one of the best places for the coops. From such a floor the droppings may be daily raked, but the apartment must be vermin-proof.

If the soil be wet or damp, it may be drained either with pipes, bushes, or open grips. The best soil is not sand, gravel or chalk, but loam, or any rich soil which produces abundant crops, for here insect life and vegetable food will be most plentiful. Early broods need shelter from wind and rain, hence the importance of double coops, or small, enclosed miniature houses with substantial wood-covered runs attached [53, 58, 60].

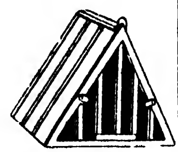
Coops. Coops are made in many forms, with and without bottoms, with doors to close up in front at night, and to form platforms by day, with shelters and with feeding places. The illustrations [52, 54, 55, 57 and 59] explain this. Coops are made in large variety at little cost, and should always be of planed and painted wood, but they should be either painted or lime-washed within each season. Ability to make coops and other appliances is one of the qualifications of the successful poultry keeper. Where wooden bottoms are employed in coops, they should be daily cleansed and sanded. Coops, however, are not always needed. As the chickens grow strong, the hens may be turned out where there is plenty of space to roam at large, and they will find a large proportion of the food they need. This freedom, however, should not be extended to the earliest months, or to land where the grass is long and wet.



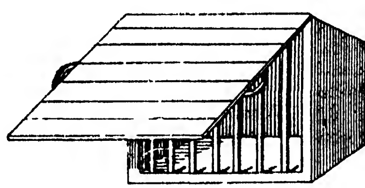
52. HENCOOP WITH SHUTTING-UP PLATFORM



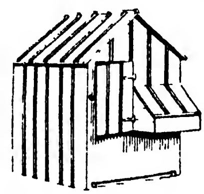
53. POULTRY HOUSE



54. HENCOOP

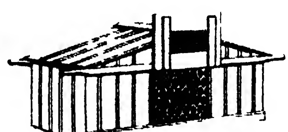


55. HENCOOP WITH SHUTTING-UP RAIN AND SUN GUARD

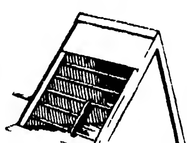


56 SMALL POULTRY HOUSE WITH NEST-BOX

57. HENCOOP



58. MOVABLE CHICKEN HOUSE

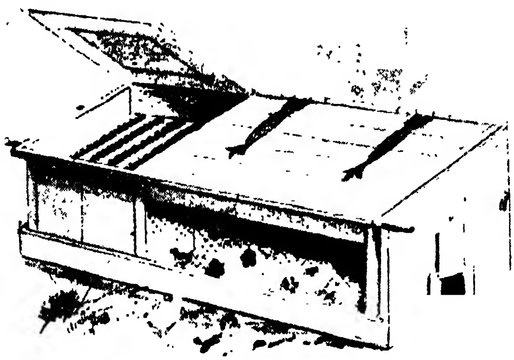


59. HENCOOP WITH SIDE-OPENING

Feeding the Chickens. There are many breeders who prefer custard made of egg and milk as the first food of chickens; others supply chopped egg and breadcrumbs for two or three days, subsequently introducing curd made from milk, boiled buckwheat, rice boiled in milk, crushed maize, wheat or barley, paste made with barleymeal, Sussex ground oats, toppings, or middlings, house scraps, dari, millet, whole buckwheat, and later, whole grain of other kinds. It is important, however, since cereals are deficient in bone-making matter, that

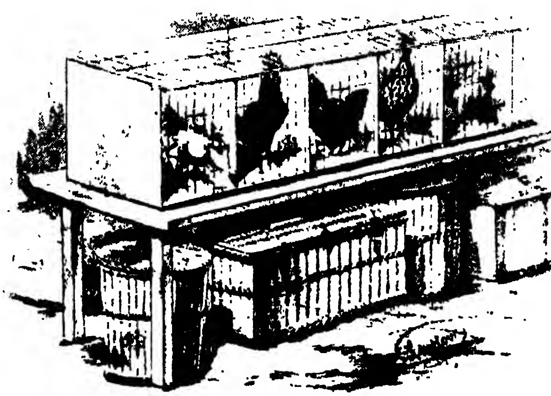
growing chickens should obtain meat, bonemeal, which may be mixed with the cereal meals, or finely crushed bones. Bone not only contains the materials necessary for assisting growth and the production of bone, as phosphate of lime, but the albuminous matter which assists in the production of lean flesh.

Feeding should be practised on the principle of little and often, diminishing the number of meals with the growth of the birds until, when adult, they require only three meals daily. Paste made from oatmeal, middlings, and the like, may be mixed stiff, and fixed on a "billot," a common practice in France, which may be made by inserting a long wooden skewer into a large thread reel. Milk is at all times most valuable, but, like water, it should be placed in a vessel in which the birds can only insert their beaks [51]. Tainted water, and soft food thrown on the ground are common causes of disease. Where fine-ground fresh bone or bonemeal is used—and but little is needed—meat is not essential. The best form of meat is the prepared granulated meat meal, or the intestines of the sheep or the bullock cleaned, boiled and minced.



60. BROODER AND RUN FOR VERY YOUNG (

Purchasing Chickens for Rearing. If it is inconvenient to breed chickens, they may be easily purchased at from two days to a month old at very reasonable prices. They are now packed, and sent long distances with great success [61]. All chickens need protection against insects, and it is a common practice to anoint the head, which is the most dangerous seat of attack, with mercurial ointment, 1 oz., powdered sulphur and crude petroleum, each _ oz., and lard sufficient for mixing. The breeder must use his own common-sense to protect his little flock against rats, stoats, foxes, and other vermin. As with hens, so with chickens, variety of food and frequent change are most advisable, but the variety may be more restricted as the birds grow.



61. EXHIBITION CAGES AND TRAVELLING BASKETS

When forsaken by or removed from the mother, the young birds may be kept in larger parties. If the weather is cold, a "cold mother"—practically a non-heated mother—may be employed, and here they will keep each other warm, while they may be protected by wire feeding runs outside. It should be an axiom to keep birds in lots of one size, but as they grow, and the sexes develop, the cockerels should be separated from the pullets, each sex being placed in a large, dry, sheltered grass run in which is a warm, dry, well-ventilated house, fitted with broad perches, not placed too high for the heavy breeds.

Feeding Adult Hens. The feeding of adult hens demands close study and attention. The composition of the food differs from that supplied to other domestic stock for two reasons—first, because the composition of the body of a fowl consists so largely of protein, the nitrogenous constituent of food; and next because the egg is exceptionally rich in the same material. The body of an unfattened fowl consists, to the extent of one-half its dry matter, of protein and no less than 8 per cent. of mineral matter, hence the importance of supplying food like bonemeal or ground bone, both of which are rich in these materials. Analyses of the entire carcases of birds have been made at the experiment station of New York State with the results given below.

In these instances, the figures of which were supported by other analyses, the entire body is represented, including bones, feathers, and intestines. Had the fat of the capon, which was a fattened fowl, been removed, the composition of its body would have closely resembled that of the

Breed.	Water.	Protein.	Fat.	Ash.
Leghorn hen	55·8	21·6	17·0	3·8
Leghorn pullet	55·4	21·2	18·0	3.4
Plymouth Rock capon	41·6	19·4	33·3	3·7

Leghorns. There is, too, a striking resemblance between the composition of the egg and of the adult fowl as regards its general proportions ["The Feeding of Animals," by Professor Jordan; Macmillan]. Whereas the dry matter of the carcases of adult hens contained 48·9 per cent. of protein, 38·5 per cent. of fat, and 8·6 per cent. of ash, the dry matter of the eggs analysed contained 49·8 per cent. of protein, 38·6 per cent. of fat, and 3·5 per cent. of ash. The protein of the egg, of which the white is so largely composed, is practically sufficient for the production of the chicken. It will, however, be instructive to quote other figures, obtained by the same experimenters, showing the proportion of food to carcase.

—	Number examined	Carcase in per cent. of live weight	Per cent. of edible dry matter in carcase	Per cent. of edible dry matter in live animal
Fowl, large ..	12	80·8	27·0	21·8
Fowl, small ..	7	78·0	27·0	21·1
Chickens	107	82·1*a*	14·7	12·1
Eggs	34	88·8*b*	26·3	23·3*c*

a Not drawn *b* After removing shells *c* Eggs with shells

In feeding the hen, not only is a mixed ration the best, but it is next to impossible to obtain the same results where the birds are regularly fed upon one variety of food.

The Value of Phosphate of Lime. The employment of a food containing phosphate of lime is most essential, and in practice it is found that the addition of bonemeal or ground fresh bone to grain food is superior to that of feeding upon meat, especially red meat, which is much richer in mineral matter than grain. If meat is supplied to hens, the white, cleaned, cooked and minced intestines of animals should be preferred. Although fat in the form of suet may be given to chickens with advantage, to encourage their growth, it is not suitable for hens, except when added in small quantities to meal for the purpose of fattening. Green or dried clover heads, and lucerne are useful additions to a poultry ration; they are believed to intensify the colour of the yolk of the egg, but while both are rich in protein, that from animal sources and particularly from bone, is regarded as the most economical. In feeding poultry, young or adult, grit should always be provided. It is essential where grain food is used, practically becoming the millstones within the gizzard, the great duty of which is to grind, and thus prepare the already softened corn for digestion and absorption. Coarse sand may be employed in the same way for chickens. All poultry benefit by the occasional use of salt. A chicken which by good feeding has reached the weight of 2 lb., in ten weeks, has increased its weight by more than 160 per cent., while a duckling which reaches 5 lb. in a similar period has made a gain of more than double this figure.

The Maintenance Ration. It must be remembered that in feeding either the hen or the chicken, a certain proportion of the food is required for the maintenance of the body or carcase. The food consumed beyond this proportion is available for the production of the egg in the one, or for the increase of the weight of the other. The weight and composition of a maintenance ration depends upon the size of the bird. Thus the Cochin requires a greater weight of food for its maintenance than the Hamburgh, but the smaller quantity of food is required for each pound of increase as between the smaller and the larger breed. Professor Jordan quotes the results of the feeding of 52 capons varying from 9 lb. to 12 lb. in weight which were fed for 158 days, and of 60 hens varying from 3 lb. to 7 lb. which were fed for 150 days. The digestible, nutritious matter required per day for each 100 lb. of live weight was as follows:

Bird	Total dry matter	Ash	Protein	Carbohydrates	Fat	Nutritive ratio
	lb.	lb.	lb.	lb.	lb.	
Capons of 9 to 12 lb.	2·30	·06	·30	1·74	·20	1 : 7·5
Hens of 5 to 7 lb...	2·70	·10	·40	2·00	·20	1 : 6·2
Hens of 3 to 5 lb...	3·90	·15	·50	2·95	·30	1 : 7·4

It will be observed that the laying hen apparently requires a ration richer in protein and ash than the non-laying hen. The same authority suggests the following as an approximate ration for laying hen.

Bird	Total dry matter	Ash	Protein	Carbohydrates	Fat	Nutritive ratio
Hens of 5 to 8 lb.	3·30	·20	·65	2·25	·20	1 : 4·2
Hens of 3 to 5 lb.	5·50	·30	1·00	3·75	·35	1 : 4·6

These figures form a basis upon which the intelligent poultry keeper can work.

Rations for the Larger Breed. A maintenance ration for a hen of the larger size may be composed of a mixture of 1 part each of maize and maizemeal, $\frac{1}{2}$ part each of ground oats, wheat middlings, and clover hay, $\frac{1}{4}$ part of fresh bone, and $\frac{1}{8}$ part of meat scraps. For laying hens of larger size the following is suggested: 1 part of maize, $\frac{3}{4}$ part each of wheat, maizemeal, and green lucerne, $\frac{1}{2}$ part each of wheat middlings, buckwheat middlings, and wheatmeal, and $\frac{2}{3}$ part of fresh bone.

Bone and peameal may be added to cereal meals for the purpose of increasing their protein value. Linseed meal or crushed linseed cake may be similarly supplied where, in addition to protein, oil is required. In feeding chickens, the quantity of dry matter in food which has been shown to be necessary for 100 lb. live weight during the first fortnight is 10 lb. This decreases by 1 lb. per fortnight, until, at the age of 12 weeks, the bird requires only $5\frac{1}{2}$ lb. of dry matter per 100 lb. live weight. The protein needed at the former period is 2 lb., diminishing to 1 lb. at the last period, while the carbohydrates, chiefly starch and sugar, required for the first fortnight are about 7 lb., gradually diminishing to $3\frac{1}{2}$ lb. at the end of three months.

Continued

WAR, THE ENEMY OF MANKIND

Militarism Perverts the True End of Labour. The Poets and Peace. Did the Boer War Save England? The True Battlefields for the Nations

By Dr. C. W. SALEEBY

WHEN we contemplate war as a fact of history and not merely as an occasional possibility of to-day we shall find warrant for studying it at this stage and not regarding it as merely one of the lesser subjects of sociology. Indeed, the relations of any society to war are amongst its most vital relations, and since they actually determine the very form and destiny of society, and have played a leading part in the past, they must be considered as all but fundamental, even though their present significance has so vastly diminished.

The Struggle between Societies. In this particular subject we may closely follow the teaching of Herbert Spencer, which has not needed nearly so much revision in later years, as, for instance, his work on the subject of marriage. If there is any part of sociology of which it is true, as we have said, that the sociologist is compelled also to be a moralist, and, unlike those who deal with other sciences, to pass judgments upon his facts, the study of war must be that part, and we may find it necessary to recognise here, as in so many other instances, a soul of good in things evil.

Our immediate subject is war in the ordinary sense of that term, and not what the French call "les luttes sociales." In the widest sense, the necessity for struggle or contest is one of the fundamental facts for the sociologist, and we shall certainly look more philosophically upon war—that is to say, upon military war—if we recognise its fundamental identity with many other kinds of social struggle; with, for instance, industrial competition, and with even "les luttes pour le travail," or the struggle for work. War, indeed, or military struggle between societies, is evidently, when we come to think of it, only the earliest, the most primitive, and the most brutal form of the "struggle for existence" as it is waged between societies.

The Workers must Destroy War. Now if these adjectives are warranted, we shall expect to find, as we do find, that in early times—though not perhaps in the very earliest times, when there was plenty of room and food for everybody—war was the permanent, chronic, normal state of all active societies. We have, indeed, here what we may recognise as the military stage of society. In those times the society that was not military would be immediately subjugated, and its identity would rapidly disappear. At this stage there could not persist such a society as that now represented by Switzerland. Fighting is the necessary and permanent business of all able-bodied men, and since its importance is supreme for the society, it follows as a natural consequence that women in such a society will occupy a humble place. The only worth of woman is as a potential mother of soldiers. There are many superfluous women, since fighting keeps down the numbers of the men. Thus we expect to find polygamy practised by the most successful men; we expect family life to suffer, as it always does, when it is opposed to militarism; we expect to find a high birth-rate but a very high infant mortality rate, as well as a very high general death-rate; we are not surprised to hear that the aged are despised or even disposed of; we find it a consistent action of the Spartans, for instance, to expose to the wolves all weakly or malformed infants; and we can at once understand the prevalence of female infanticide. All these are characters which make for the bestialisation of the society; displayed in extreme degrees, as they were by the Spartans, they must even make for its extinction. Yet, at the military stage, the military interest is foremost, and whatever not unduly serves it makes for the life of the society in its struggle with its neighbours.

War as a Social Organiser. Our judgments in the main are adverse. Neither the lover of the good nor the lover of the beautiful can admire such a military society, yet, as impartial students, we have to recognise the soul of good in things evil even whilst we regret the necessity for the evil. We have even to recognise that the military stage, given the facts of nature and human nature, was actually necessary, inevitable, and ultimately beneficial in the development of human society. *It was, indeed, the necessity of war that led to the beginnings of social organisation.* In the first stage of the evolution of the social organism we find—in remarkable parallel to the individual organism, as Spencer pointed out—"the masters, who, as warriors, carry on the offensive and defensive activities and thus especially stand in relation to the environment; and the slaves, who carry on inner activities for the general sustentation, primarily of their masters, and secondarily of themselves." Indeed, we find that "everywhere the wars between societies originate governmental structures, and are causes of all such improvements in those structures as increase the efficiency of corporate action against environing societies. . . . The governmental military organisation of a society is initiated by, and evolves along with, the warfare between societies." In other words, "there is thus evolved that part of its governmental organisation which conduces to efficient co-operation against other societies." The evil is undoubtedly evil, and yet—so strange is human life—it may be the parent of the good.

The Military Society. What, then, are the characteristics of the military or earliest important stage in society? As Herbert Spencer well puts it, "the militant type is one in which the army is the nation mobilised while the nation is the quiescent army, and which therefore acquires a structure common to army and nation. The trait characterising the militant structure throughout is that its units are coerced into their various combined actions. As the soldier's will is so suspended that he becomes in everything the agent of his officer's will, so is the will of the citizen in all transactions, private and public, overruled by that of the Government. The co-operation by which the life of the militant society is maintained is a *compulsory* co-operation."

These are facts which have to be reckoned with in the present controversy between the ideals of individual liberty, on the one hand, and collective authority on the other hand. The earliest stage of societies, which is the military stage and the lowest stage, is also the most completely collective stage. There is no individual liberty, there is scarcely any possibility for the development of the individual life; there is "compulsory co-operation."

In passing judgment upon this stage we shall find ourselves influenced by our beliefs regarding heredity, which has been admirably discussed in another course. Herbert Spencer followed Lamarck in believing that acquired characters are inherited. He was therefore able to infer that the military stage of society has been of great psychical value as a means of discipline. Our present capacity for self-restraint and self-control, such as it is, for obedience to authority, for long-sustained and assiduous labour—all these may be supposed, on the Lamarckian theory, to have been inherited by us in consequence of the military education of our forefathers. If, on the other hand, we believe, as we are compelled to believe, that Lamarck and Spencer were wrong, and that acquired habits of discipline cannot be transmitted to children, we shall be unable to thank the military stage of society for having done us such a service. This, of course, is by no means to say that the stage was not necessary on the way towards the evolution of higher social forms.

The Industrial Society. There is now extant no society which is purely military. The whole conditions of life have profoundly changed. Man can no longer live by war alone, and we may hope and believe that that stage is for ever past. But we may best recognise the present relations of society to war if we consider the next sharply marked stage of society. We shall then see that the nations of to-day, in general, display in varying degrees the characters of both these stages, and we shall see reason to believe that they suffer greatly from their present incapacity to slough off the disabling and degrading armour of war.

The next great stage that societies display is the industrial stage. The characteristic of the industrial type is that it does not live by war alone. Instead of stealing the means for life from its neighbours, and instead of making slaves of its neighbours, or being enslaved by them—the enslaved people then performing the necessary industrial work—the industrial type of society devotes itself, as a whole, to industrial activities, just as the military type devoted itself, as a whole, to military activities. There is still co-operation within the society, but it is now not compulsory, but voluntary. Says Spencer:

"All trading transactions, whether between masters and workmen, buyers and sellers of commodities, or professional men and those they aid, are effected by free exchange. This relation of *voluntary* co-operation, in which the mutual rendering of services is unforced and neither individual subordinated, becomes the predominant relation throughout society in proportion as the industrial activities predominate. Daily determining the thoughts and sentiments, it produces social units whose mental structures and habits mould social arrangements into corresponding forms."

The Interesting Case of Germany. Reading these words, we must pass our own judgment upon them, not accepting the authority of even this mighty thinker, and we may ask ourselves whether the voluntary co-operation of industrial society may not sometimes be more apparent than real, and whether the present tendencies do not show that individual liberty may be, in some ways, as limited in practice in an industrial society as in a military one. Of the greatest importance are the changes which ensue when a society undergoes a metamorphosis—which may often be very sudden—from the military to the industrial type; and no less interesting are the possibilities of a degeneration from the industrial back to the military type. The societies which we ourselves know are highly unstable in these respects. If we take, for instance, Great Britain and Germany, we see that while neither conforms to the military type, both are great military powers; and that while neither conforms to the industrial type, both are great industrial societies. The rise of industrial Germany was extremely sudden, but did not involve a disappearance of militancy; and Germany in general very well shows, not only in its military, but also in its industrial aspects, those features of compulsory co-operation and regulation which are especially characteristic of the military type. Again, though modern Germany owes its success to its industrial activity, that activity is subordinated to the military end, and this introduces us to a very interesting consideration.

The Three Ends of Labour. We may recognise with Spencer three distinct purposes, real or ideal, to which the products of industry may be put. Of these the lowest, the most brutal, and the most unworthy, is the purpose of maintaining a militant organisation. Here, indeed, the people labour for that which is not bread. The advances of science and civilisation are prostituted to the perpetuation, on a scale unparalleled in the past, of the militarism which, in the past, was a necessary condition of

the survival of any society. It may be possible rudely to estimate the status of the foremost nations of the world in this respect. We may leave pitiable Russia out of the account. To Germany must be allotted the bad pre-eminience of the almost complete prostitution of industrialism to militarism. We ourselves groan under scarcely less a burden. Of course, there may be explanations and excuses, but here we are not concerned with them. On the other hand, we may contrast the United States of America and France. In the first instance, owing doubtless mainly to geographical and economic considerations, a far higher plane has been reached—the army being not the master of the nation, as in Germany, but its servant. In wonderful France, the home of so many great ideas, and also, of course, the learner of a recent terrible lesson, we find militarism more despised on principle than in any other great nation in the world. France has yet to recover from the war of the last generation, and even more from her service of the greatest soldier and criminal of all time. She now points the way to a forthcoming age when the names of all soldiers shall be forgotten.

An Intolerable Waste of Labour. Then there is a second or higher purpose - vastly higher—to which industrialism may be put, and amongst the less military of the great nations, as well as amongst ourselves, we may observe this stage. Industry is now no longer prostituted to the maintenance of armies and navies. Except for purposes of defence—which assume the possibility of offence on the part of neighbours—a military organisation does not serve the worker. He is not allowed to enjoy what he earns. The labours of hundreds of thousands of men during the whole year are largely robbed of their personal reward in order that a battleship may be built. It is one of the fine and true ideas to be found in modern socialism that war is against the interests of workers of all countries, and that war may end if they come to an agreement with one another. It is outrageous that the labours of thousands in France should do absolutely nothing more than serve to neutralise the labours of thousands in England. Why should they not agree that it is not worth their while to fight each other, and, by their agreement, obtain the rewards of their own industry? This great idea has only to be disseminated amongst the workers of all countries to make war impossible, for money is the sinews of war, and they are its chief creators. If we take a non-military society, such as Switzerland, we find Spencer's second stage realised. The products of industry are now employed "for material aggrandisement." Life becomes less hard, there is leisure, and comfort, and prosperity; the life-blood of the people is not drained.

The Highest End of Industrialism. But there remains a yet higher stage, and already we find traces of it. Industry is still pursued, but its products are now turned neither to military purposes nor exclusively to "material aggrandisement." Such a society devotes them "to the carrying on of higher activities." This opens out a great ideal, which it is worth while to consider further.

In studying war we find, as we hinted at the beginning, that we are actually studying *the types of society*—the two studies cannot be dissociated, for its relations to war go far to determine the type of any society. The types which we have already recognised are the *military* and the *industrial*. We have further observed that, as a fact of to-day, we must join these two terms together, and describe as *military-industrial* our greatest societies. But our consideration of the purposes to which the products of industry may be put will allow us to introduce a new term.

The Spiritual Type of Society. The present writer looks forward to a type of society which, in contrast to the past military type and the present military-industrial and industrial types, he has elsewhere ventured to call the spiritual type. In it we may hope to find realised the dream of Spencer; the products of industry will then be devoted to the carrying on of higher activities. Indeed, we are already entitled to anticipate a time when the products of industry will require for their production only a quite insignificant proportion of the whole sum of human activities. It is not merely that such a society will not waste its energies upon military aggression or defence not desiring the one and not needing the other. It is not even that industrial competition with its neighbours may become as relatively uncommon as actual war is nowadays. It is that men's material wants will not involve the expenditure of any large part of their social energy. As the writer has said, "In the spiritual type of society, where material wants are easily satisfied, men will be justified in devoting large portions of their time to those activities with which most of us are now justified in filling only the leisure part of life. International competition will remain to show itself in a noble patriotism, which rejoices—to use the illustration suggested by Carlyle—more in our Shakespeare than our India. . . . To the industrialism of the present—which is at present a legitimate means to the legitimate end of the fulness of life—there will succeed, in the spiritual type of society, a nobler industry concerned with the accumulation of riches which neither moth nor rust can corrupt, stored in the mansions of the mind, where thieves cannot break through nor steal."

War for the Best. It is in such an age that art and thought will enter into their heritage, and above the champions of destructive and constructive imperialism will be ranked the champions of constructive beauty and constructive thought. There will still be "les luttes sociales"; but they will have undergone an utter transmutation. Men will not fight for gold, but they will compete for the lowest death-rate, the lowest crime-rate, for the construction of the best conditions of education, for the making of the noblest music and poetry, and for the discovery, recognition, and service of the highest truths. We are preparing ourselves for the study of a subsequent subject when we observe that in Russia there

is an autocracy—if not in a very real sense—and an almost absolute monarchy in Germany; whilst, at the other extreme, in the United States and France we find democracies. We must ask ourselves whether there is not a fundamental connection or correlation between various forms of government and militarism; but before we do so, and before we contemplate the modern tendency to a complete transformation in the nature of the weapons by which societies still fight with each other, let us broadly contemplate war as a fact.

Physical Courage is not a Virtue. There are those who, often sincerely and disinterestedly, often under the influence of a not ignoble patriotism, yet more frequently in self-interest or class-interest, still sing the praises of war. They deify brute courage, one of the least admirable traits of man; they are adherents of the *religion of enmity* six days in the week, though on the seventh they profess the *religion of amity*. This famous phraseology is Spencer's, and from him we may quote a stinging paragraph of irony in which the common over-estimate of physical courage is disposed of:

"Worthy of highest admiration is the Tasmanian devil, which, fighting to the last gasp, snarls with its dying breath. Admirable, too, though less admirable, is our own bulldog—a creature said sometimes to retain its hold even when a limb is cut off. To be admired also for their 'pluck,' perhaps nearly in as great a degree, are some of the carnivora, as the lion and the tiger, since, when driven to bay they fight against great odds. Nor should we forget the gamecock, supplying as it does a word of eulogy to the mob of roughs who witness the hanging of a murderer, and who half condone his crime if he 'dies game.' Below these animals come mankind, some of whom, indeed, as the American Indians, bear tortures without groaning. And then, considerably lower must be placed the civilised man, who, fighting up to a certain point, and bearing considerable injury, ordinarily yields when further fighting is useless."

The Battle of Dumdrudge. And here is one of the most famous passages that Carlyle ever wrote, from "Sartor Resartus":

"What, speaking in quite unofficial language, is the net purport and upshot of war? To my own knowledge, for example, there dwell and toil, in the British village of Dumdrudge, usually some five hundred souls. From these, by certain 'natural enemies' of the French, there are successively selected, during the French war, say, thirty able-bodied men. Dumdrudge, at her own expense, has suckled and nursed them; she has, not without difficulty and sorrow, fed them up to manhood, and even trained them to crafts, so that one can weave, another build, another hammer, and the weakest can stand under thirty stone avoirdupois. Nevertheless, amid much weeping and swearing, they are selected, all dressed in red, and shipped away, at the public charges, some 2,000 miles, or, say, only to the south of Spain, and fed there till wanted. And now to that same spot in the south of Spain, are thirty similar French artisans, from a French Dumdrudge, in like manner wending; till at length, after infinite effort, the two parties come into actual juxtaposition, and Thirty stands fronting Thirty, each with a gun in his hand. Straightway the word 'Fire!' is given and they blow the souls out of one another, and in place of sixty brisk, useful craftsmen, the world has sixty dead carcases, which it must bury, and anew shed tears for. Had these men any quarrel? Busy as the devil is, not the smallest! They lived far enough apart; were the entirest strangers; nay, in so wide a universe, there was even, unconsciously, by commerce, some mutual helpfulness between them. How then? Simpleton! Their governors had fallen out, and, instead of shooting one another, had the cunning to make these poor blockheads shoot. Alas! so is it in Deutschland, and hitherto in all other lands; still as of old, what devilry soever kings do, the Greeks must pay the piper!"

But there are other grounds; there are other opinions which the lover of peace must meet before he is entitled to pronounce a final judgment upon war. We have just painted to the best of our imperfect ability the picture of such a society as may be, but we have to answer those who, though not accepting the Lamarckian theory of heredity, and though entirely ignorant of Spencer's opinion of war as an organising agent in the early stages of society, yet maintain on various grounds that any society which abandons war is on the way to degeneration.

The Delusion of the Poets. War has served men in early stages by leading to the extinction of wholly unfit races; it has served as a means of discipline; it has had a marked effect upon the development of the arts; it has led to the formation of large societies which are able occasionally to be at peace and in which the division of labour can be effectually carried out. War, indeed, "brings about a social aggregation which furthers that industrial state at variance with war, and yet nothing but war could bring about this social aggregation." Are we warranted in adding to all these advantages the opinion that peace means the decay of men?

Some instances of this opinion may be quoted. In a sonnet of Wordsworth's we find these lines:

"When I have borne in memory what has tamed
Great Nations, how ennobling thoughts depart
When men change swords for ledgers . . ."

The same idea is expressed by Gibbon in language which shows that the possibility of doubting it never occurred to him:

"It was scarcely possible that the eyes of contemporaries should discover in the public felicity the causes of decay and corruption. The long peace, and the uniform government of the Romans, had introduced a slow and secret poison into the vitals of the empire."

This evidently is a vital question to us as sociologists, because it appeals to what we have declared to be our only valid criterion. We have insisted at length upon the proposition that only by reference to its effects upon human nature can we pronounce judgment upon any social custom or practice.

Is Peace a Whited Sepulchre? If it be true that individual character is raised by war and degraded by peace, as is the belief of poets and most pre-scientific historians, then we must dismiss as mythical our picture, or any picture, of an elevated society existing without war. We must regard anti-militarism as a principle making for national degradation, and *peace as a whited sepulchre*. Unquestionably our criterion is valid, and must be applied here. However reluctantly, we have no choice but to accept the fact, if indeed it be a fact, that this horrible thing is a necessary condition of the virtue of mankind. It is certainly one of the most horrible doctrines ever conceived or taught. Is it true? Is virtue really nothing more than *virtus?* Is the history of the word a history of degradation, like the history of most words, or is it for once a history of elevation? Is all virtue founded in manliness, all goodness in strength? Is forgiveness weakness, and is it a debasement of language to speak of the virtue of mercy? Or, on the other hand, have the ages gradually learnt that virtue is not necessarily manliness—by which is often meant beastliness? Is peace necessarily enervating, as the historians say, and would our own nation have sunk into moral atrophy and degradation if it had not been for the Boer War, as Mr. Balfour has hinted?

The Absurdity of Half a Truth. The present writer believes that the conventional opinion of peace is based upon a half perception of the truth that man must strive—must strive and try to conquer. What is not true, but abominably false, is that there is no salutary striving except on the battlefield. "Peace hath her victories no less than war." The soldierly virtues are of value in every sphere. There is moral as well as physical courage. It is true that the nation or individual which ceases to struggle, ceases to progress; in *that* sense peace is enervating. We may quote a biological illustration of the intestinal parasites. The tape worm has practically ceased to struggle; it needs nothing more than arrangements for "hanging on"; it need fear no enemies; its surroundings are warm and cosy; its food is even digested for it by its host, but the measure of its success is the measure of its failure. There is no more despicable creature.

It is not ledgers that have destroyed great nations. Industrial warfare is very real warfare, and we may admit that for a very large number of men it serves the same disciplinary purpose as military warfare served for their remote ancestors. For such men and such societies, the danger arises when neither military nor industrial warfare is any longer necessary. Just as the individual who loafs, does not need to work, and has no higher interests, becomes a "waster," so does the society which, like the Roman populace, shouts for "panem et circenses"—bread and games. Roman society became a "waster." Average human nature will always find some mischief still for idle hands to do, and this mischief—it is common experience—is very commonly concerned with the lower instincts of man. Thus, marriage and the family go by the board, and thus Rome fell. We would very earnestly direct the reader's attention to the foregoing paragraphs, for it is our opinion—a biassed one, perhaps—that they represent a really serious contribution to the subject.

The Greatest Evil in the World. But, as the reader knows, we have entered the era of scientific history, and it is not fair to it to quote Gibbon as if nothing had been done since his time. Against his opinion, which we may call the common literary opinion—only too often expressed by the author of "Sartor Resartus"—let us place the opinion of that great writer, historian, sociologist, and pioneer, Henry Thomas Buckle. We quote from the fourth chapter of his masterpiece, already referred to, and the reader will see where he places war amongst human ills. After speaking of the Spanish Inquisition, and defending the moral character of the inquisitors, whom he regards not as knaves, but fools—not hypocrites, but enthusiasts, he says:

"It is to the diffusion of knowledge, and to that alone that we owe the comparative cessation of what is unquestionably the greatest evil men have ever inflicted on their own species. For that religious persecution is a greater evil than any other is apparent, not so much from the enormous and almost incredible number of its known victims, as from the fact that the unknown must be far more numerous, and that history gives no account of those who have been spared in the body in order that they might suffer in the mind. . . . who, thus forced into an apostacy the heart abhors, have passed the remainder of their life in the practice of a constant and humiliating hypocrisy. It is this which is the real curse of religious persecution. For in this way, men being constrained to mask their thoughts, there arises a habit of securing safety by falsehood, and of purchasing impunity with deceit. In this way, fraud becomes a necessary of life; insincerity is made a daily custom; the whole tone of public feeling is vitiated, and the gross amount of vice and of error fearfully increased. Surely, then, we have reason to say that, compared to this, all other crimes are of small account, and we may well be grateful for that increase of intellectual pursuits which has destoyed an evil that some among us would even now willingly restore."

The Second Greatest Evil. "The second greatest evil known to mankind—the one by which, with the exception of religious persecution, most suffering has been caused—is unquestionably the practice of war. That this barbarous pursuit is, in the progress of society, steadily declining must be evident, even to the most hasty reader of European history. If we compare one century with another, we shall find that for a very long period wars have been becoming less frequent. . . . It will surely not be pretended that the moderns have made any discoveries respecting the moral evils of war. . . . That defensive wars are just, and that offensive wars are unjust, are the only two principles which, on this subject, moralists are able to teach."

The Destruction of the Military Spirit. Buckle goes on to argue with tremendous force that, as in the case of religious persecution, so in the case of war it is the human intellect that has determined progress, "that every great increase in its activity has been a heavy blow to the warlike spirit." "As civilisation advances . . . military ardour is balanced by motives which none but a cultivated people can feel." "By an increasing love of intellectual pursuits the military service necessarily declines not only in reputation, but likewise in ability." He goes on to show how, in consequence of these superior attractions of other professions "as society advances, the ecclesiastical spirit and the military spirit never fail to decline. . . . The military class, taken as a whole, has a tendency to degenerate," a proposition he brilliantly proves.

The magnificent chapter from which we have chosen a few passages was published in 1857, the year of Comte's death, the year of Spencer's introduction of the term "evolution," and two years before Darwin's masterpiece gave history and the past a new meaning. We earnestly commend this chapter to the reader. But at the least let him remember the opinion of this great thinker—that religious persecution is the greatest of all the evils of mankind and that war is the second. Then let him reflect, as Buckle might have reflected, on the combination of these two evils which transcends them both—*the wars of religion*. These have bathed Europe in blood for nearly two thousand years; they have "made a goblin of the sun," have immeasurably delayed progress, have again and again submerged the good and the true, and they have been waged in the name of Him who "went about doing good," and said "They that take the sword shall perish by the sword," and "Blessed are the peacemakers, for they shall be called the children of God."

The Falsest Idea in Politics. Looking now upon war as merely the oldest, commonest and most brutal form of the selfish struggle between societies, let us endeavour to grasp a supreme truth which is emerging slowly into recognition, and which will guide us to the direction in which we may expect to find the ultimate disappearance of war, and of all such struggles.

A true sociology, like a true morality, utterly denies the truth of the all but universal assumption that what injures one nation benefits another. In a recent economic controversy we have seen this taken for granted—with the single exception of a noble quotation from a far-seeing and noble woman, Mrs. Browning. The sentiment which she expressed was that the truly just statesman would hesitate before adopting a policy which benefited, say, ten at home and ruined a thousand across the frontier. But here sociology comes in and shows that there is no antagonism between patriotism and morality, even in such a case. It seems to be thought that there is only a certain finite amount of success and happiness for the nations of the earth, and that if one, having so much happiness or success, obtains more, some one else must necessarily suffer; and, furthermore, that if any member suffers some of the others must necessarily gain. Of all false and vicious political ideas this is perhaps the falsest, the most vicious, and the most utterly disastrous.

Man's Brotherhood to Man. The truth of that great organism called human society is the same truth as St. Paul expressed of the Early Christian Church of Corinth by analogy from the human body. "Whether one member suffer, all the members suffer with it; or one member be honoured, all the members rejoice with it." It is hinted at again, though far more might have been made of it, in the *locus classicus* which we have quoted from Carlyle. Speaking of the French and English artisans who blew the souls out of one another, he says, "there was even unconsciously, by commerce, some mutual helpfulness between them." We admit, of course, that temporary benefit will ensue to the manufacturer of a particular kind of cloth, even though a foreign industry is thereby ruined; but in the long run the prosperity of one nation makes for that of another, even if only because it makes it a better customer. Politics and governments lag behind, but as in the case of science and music, so certainly in the case of commerce, the whole of civilised society is now one huge organism, and an earthquake in San Francisco will affect the price of steel in London, a flood in India may throw thousands of Lancashire operatives out of work, whilst prosperity and industry and success in Lancashire will lower the price of cotton goods in far countries, and so benefit their inhabitants. The other—the fact that one nation's failure may be another's success—is the temporary and the accidental; *this* is the eternal and essential truth.

The Human Commonwealth. This leads us on to the culminating stages of a great conception, the earlier stages of which we must soon briefly consider. Herbert Spencer's argument surely might have been carried a little further. Military warfare, we have seen, leads now to industrial warfare, and what is that effecting but the welding of the nations by common interests into a still larger society, which will at the last embrace the whole of mankind? This, of course, is a "poet's dream." But if we look beneath the superficial and the blatant we may suspect that there is more in it. We must not judge the separateness of nations by the separateness of their governments. The Governmental forms of a nation are conservative. In the case of nearly all the European nations, they are merely survivals. Even in the case of separate republics, their separateness misrepresents the facts. Political frontiers are *artificial*, but the dependence of man upon man is *natural*, and is a fact which they cannot destroy, though in all ages they have injured him by interfering with it. Thus we begin to see the great world-meaning of the famous line of the Roman poet, Terence: "Homo sum; humani nihil a me alienum puto," "I am a man, and everything human is my concern."

Continued

MINOR RAILWAY DEPARTMENTS

The Railway Clearing House and Its Work. Science in Modern Railway Work. Legal and Sundry Departments

By H. G. ARCHER

UNTIL the year 1842 the working of through traffic—that is, traffic originating on one line and passing over one or more continuous but separate line or lines—was cumbrous and vexatious, each company collecting its own tolls, and keeping its own accounts. In that year Mr. Kenneth Morison propounded and successfully inaugurated his clearing system, by which the foreign or through traffic of the companies is accounted for by the terminal companies interested to the Clearing House, the companies receiving their relative proportions through that channel.

The Railway Clearing House. The Clearing House performs a kind of work which could not have been performed by the companies, no matter how amicably disposed they might have been. It maintains perfect accord among all manner of conflicting interests. Once a party to the Clearing House system, a company knows it must abide by its decisions. However, any company may withdraw at will by giving one month's notice under seal, or a company may be expelled by the votes of two thirds of the delegates present at a meeting specially convened for the purpose.

The travelling public seldom realise how much they owe to the clearing system, for by means of this institution they, both as freighters and passengers, are saved much trouble and annoyance. For example, a passenger can book for a journey, say, from Penzance to Wick, and one little piece of pasteboard franks him over several separate and absolutely distinct railway properties. Without the system he would be burdened with a book of coupons, to vouch him over each railway in turn, or might even be compelled to take a fresh ticket at every junction of the different companies' lines.

"Like most great institutions," writes Sir George Finlay, "the Railway Clearing House had a very humble commencement, for it began its operations with a staff of only four clerks, and dealt with the traffic of only four railways, controlling an aggregate mileage of 418 miles; but its growth has only been paralleled by the growth of the railway system itself." Every railway of importance is now a party to the Clearing House, the clerical staff of which numbers upwards of 2,500, while there are, in addition, some 500 "number takers" employed up and down the country, whose business it is to examine and report upon the vehicles of trains passing through important junctions. The original home of the Clearing House was a small house in Drummond Street, near Euston Station, but before many years had elapsed its operations attained such magnitude that a move was made to its present home, the huge building in Seymour Street, N.W. England and Scotland are represented in the institution in Seymour Street, while Irish business is transacted in the same form at the Irish Railway Clearing House in Kildare Street, Dublin, which was established in 1848. The work of the Railway Clearing House is divided into departments, of which the three largest and most important are as follows: the Merchandise, the Coaching, and the Mileage Departments.

The Work of the Merchandise Department. The Merchandise Department is charged with the apportionment month by month of the receipts derived from the carriage of all "through" goods, cattle, coal, and mineral traffic. The department is supplied every month with returns from all stations, giving full particulars of all such traffic. Every station sends in two distinct forms, one concerning the "outwards," or forwarded traffic, which is printed in black, and the other relating to the "inwards," or received traffic, printed in red. These abstracts state the character of the goods, their weight, the rate per ton, the charge, and whether it is "paid," or "to pay," the number of the waggon in which the consignment travels, and the name of the owner of the waggon. The two abstracts are carefully compared, and steps taken to rectify errors or discrepancies between them.

The monthly settlement is arrived at as follows: first, all total receipts between a pair of stations which amount to less than £1 are thrown out and credited to the "light traffic fund." Next, taking the remaining receipts from the traffic which has passed between each pair of stations, the terminal allowances, fixed tolls, and amounts "paid on"—that is, disbursed by the forwarding company for any special service rendered, are deducted. Thirdly, the residue is divided by mileage between the different companies concerned, so that each company gets a due proportion according to the distance it has carried the traffic. Lastly, to obviate a plethora of small accounts, the amounts credited to the "light traffic fund" are divided among the different companies in the ratio of their gross receipts from the heavier traffic.

"Clearing" the Coaching Traffic. The Coaching Department is charged with the division of receipts on all "through" traffic by passenger train—namely, passengers and their luggage, horses, carriages, dogs, parcels, fresh fish, perishables, etc.

The passenger traffic is dealt with monthly. The booking clerks render every month to the Clearing House a return specifying the through tickets issued, and every stationmaster has to forward to the Clearing House all tickets

collected at his station during the month and issued by any company other than his own, save that the tickets in which two companies alone are interested are not checked by the Clearing House unless they are issued and collected by the same company.

The receipts derived from "through" tickets are divided by mileage, but no company may receive out of a through rate more than its local fare, which means that some companies' mileage proportions have to be reduced to their local fares, and the balance divided among other companies whose proportions do not come up to the amount of their local fares. The remaining items in the coaching traffic are settled half-yearly, and here, again, occurs a light traffic fund, this time limited to 5s. On the parcels, fish, and perishable traffic, terminal charges have to be taken into consideration, whereas no terminal charge is levied on horses, dogs, and carriages. Here it may be noted that it was only by the adhesion of the Railway Clearing House that the Post Office was able to establish the Parcels Post under the Act of 1882. The great difficulty that attends this phase of the Clearing House settlement lies in tracing the route by which parcels, etc., have travelled. Theoretically, the way-bills that ought to accompany all parcels, and which are supposed to be stamped at each junction, should explain matters, but parcels and way-bills are apt to get separated, and the stamping of way-bills is frequently omitted.

The Mileage Department and its "Number Takers" The Mileage Department keeps the mileage accounts of the various companies in the matter of rolling stock of one company passing on to the territory of another, and attends to the question of demurrage for detention of carriages, waggons, and tarpaulin sheets.

The staff of "number-takers," whose members are found at every junction of two railways, records the number and description of every vehicle and sheet that passes a junction going from one line to another. In addition, every station receiving foreign stock makes a similar return, which shows how the latter got there and what was done with it. Each company's stock is shown separately under three headings—namely, Carriages, Waggons, and Sheets. Fines are levied if stock be not returned to the owning company within a legitimate time, as follows: first-class passenger carriage, 10s. a day; second or third class carriage, 6s. a day; and ordinary low-capacity waggon, 3s. a day; while sheets are charged 6d. for the first day, and 1s. for every succeeding day up to 60, when the fine stops, as it is considered that the owner has then received the value of the sheet. The demurrage settlement takes place monthly.

Organisation and Staff. The Clearing House business is regulated by a chairman, elected annually, and by committees of the traffic officers of the various companies—the general managers, goods managers, and superintendents—who sit once a quarter in the Clearing House premises. The two last classes of officers sit in the same week on separate days, and the former a few weeks later, to revise and approve the minutes of proceedings.

The working expenses of this vast and admirably managed organisation, which makes no profit and incurs no bad debts, are borne by the companies in the ratio of the amount of business done on their behalf.

To obtain a junior or apprentice-clerkship in the Railway Clearing House application must be made to the secretary, and approved candidates have to pass an ordinary clerkship examination. The Clearing House "number-takers" join the service as lads, after they have been medically examined as to sight and physical soundness. Lad "number-takers" are posted to one or other of the junctions where waggon numbers are recorded, and begin to learn their duties by making out returns. Subsequently they are put to work in the yards under older hands.

The Chemist and the Railway. The chemist has always filled an important rôle in the locomotive department of a railway, and when it is considered that this department—with which, as a rule, is incorporated the carriage and waggon department—forms the great spending arm of a railway company, it becomes easy to understand how he should be the man to whom the locomotive engineer looks to point the way towards effecting economies. Every day the scientific side of the railway profession is coming more to the front, since an increasing number of solutions to questions capable of definite scientific treatment is constantly being discovered. Thus there are more and better openings for railway chemists, while the field of employment is no longer confined to a locomotive department laboratory, but also embraces that of a general engineering chemical laboratory. The two laboratories are, however, kept distinct, for although many of the chemical and physical investigations which are performed therein cover the same ground, the object in each case is different, necessitating a different kind of analysis. For example, there is the scrutiny of water. In the locomotive laboratory the chemist is concerned only with the quality of the water for feeding boilers. He has to examine it in order to see that it does not contain an undue proportion of chalky matter, which would deposit scale upon the tubes and firebox plates, and so impair their efficiency as conductors of heat from the furnace to the water. Again, he analyses it to see that it does not contain any corrosive salts, such as magnesium chloride, which would cause the structure of the boiler itself to corrode.

Scope of the Engineering and Locomotive Laboratories. In the engineers' laboratory the chemist has to concentrate his attention upon the suitability of the water supply for domestic purposes. A railway company owns hundreds of cottages and houses up and down the line for housing its employees, and all these dwellings must, of course, be supplied with a pure water supply suitable for both human consumption and domestic purposes. And the same rule holds good in the case of stations.

The examination of the different kinds of oil for the lubrication of the locomotive is a most important feature of the locomotive chemist's duty; and the other sorts of oil which are employed in the paint-shop for mixing the paints and varnishes used to protect and decorate the outer surface of engines and rolling stock likewise demand his attention. The engineers' chemist also deals with oils—those for the paints used to cover all woodwork. Then photometric work is common to both establishments. The locomotive chemist tests the oil for the signal lamps, together with the gas-burners and incandescent mantles for the lighting of the carriages, while the engineers' chemist investigates the qualities of every means of illuminating stations and offices. The efficient lighting of station premises is a subject on which advertisers have a say.

Things which concern the locomotive chemist alone are the steel analysis and metallurgical work generally, in the case of those railway companies which have their own steel works; the analysis of pig iron, coke, and various other materials for the ironfoundry; the analysis of copper-plate for fireboxes, copper tubes for the locomotive boiler, and bronze bars for firebox stays; the analysis of the materials for bearing brasses and bronzes, and the examination by combustion in a calorimeter of the coal by means of which water is to be converted into steam to propel the trains. The coal for the locomotives must not contain much fusible ash, otherwise it is liable to choke the tube ends in the firebox and prevent the boiler from steaming properly. The composition and quality of its ash, together with its heat-giving qualities, can be determined only by an exhaustive calorimetric test.

The engineers' chemist has his own peculiar field in analysing the creosote for sleepers and the cement for buildings, while some companies ask him to conduct the most searching investigation in regard to broken rails.

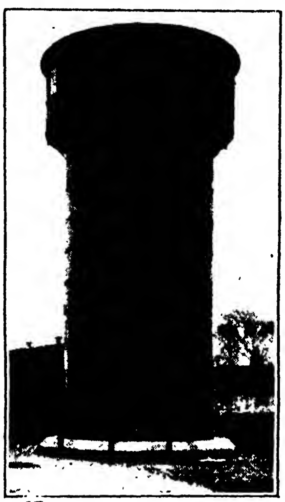
The Inquest on Fractured Rails. The London and North-Western is the only railway that rolls its own rails. The plant at Crewe has a capacity for turning out 45,000 tons of rails annually, the mill being driven by a 700-horse power engine. In the purchase of rails from private manufacturers, a company's inspector has the lot laid out on a bank, in order to scrutinise each rail. Quite 30 per cent. are rejected or sent back to be straightened; but of course the inspector cannot detect inherent flaws. To get at the truth of the latter, the following procedure has been adopted. The fractured rail is sent to the engineers' laboratory accompanied by a report from the district engineer, stating the date when discovered (a ganger finding a broken rail is suitably rewarded), and the locality; whether the rail belongs to an "up," "down," or a single line; particulars of the fracture, accompanied by drawings; the distance of the fracture from the nearest bearings on each side, and the distance from the nearest joint; if in the double line; whether on the leading or trailing side of the nearest side; if the rail was on curve, the radius of the curve, and whether on the inside or outside of the curve; the period the rail had been in use; the average number of trains passing over it per day; the section; the weight per yard when new, the actual weight per yard at date of fracture; the loss of weight per yard, and whether the rail had been turned or not. The chemist cuts two slices as near as possible to the fracture, and if it is a long split the slices come right across it. One slice he polishes, and then etches with 20 per cent. of sulphuric acid for two hours at 60° C. The slice is next photographed, and from its appearance he selects portions of the other slice for microscopic examination, taking a piece from the centre of the head, a piece from the web, a piece from the side of the head, and a piece from near the running edge. These pieces are polished, etched with sulphuric acid, and photographed under the microscope. The rail is also analysed chemically, drillings for analysis being taken either from close to the fracture or from one or other of the slices. Finally, a detailed report, illustrated with microscopic photographs, is forwarded to the chief engineer.

The Evils of Hard Water. There is now no feature of locomotive operation and construction which constitutes so great a problem as the maintenance of boilers, and this is intimately associated with and affected by the character of the feed water. When hard water is evaporated in a boiler, the incrusting impurities are deposited inside the boiler, or on the boiler tubes in the form of scale. The accumulation of this scale not only increases the cost of fuel, but, by placing insulation between the boiler and the water, allows the sheets and flues to become overheated, subjecting them to extremes of expansion and contraction. Then, too, it is necessary to shut down the boiler once or twice a week to remove the scale by "washing out," which operation is referred to in the section dealing with the work of the enginemen. Again, corrosive salts, such as magnesium chloride, in hard water cause the structure of the boiler itself to corrode, thus shortening its life.

Water Softening for Railway Purposes. Of necessity, railways have located their watering stations where there is an abundance of water, without regard to its quality. More recently, however, the keen competition of new industrial conditions has led progressive managers to appreciate the immense saving that can be effected by having a soft water for use in boilers. To secure the best and most economical results from water to be transformed into steam, it must be softened—that is, freed from scale-forming impurities. Considerable attention has been lately devoted to the subject, and different systems of water softening are now being adopted. Many large plants have already been established at important locomotive centres in this country—notably, on the North London Railway, outside Broad Street Station, where it is stated that no less than 70 tons of deposit are collected annually; on the Great Western Railway, at Goring, where the water for the track

troughs is pumped from the adjacent river, and at Aldermaston, near Reading; and on the North Eastern Railway, at Hessel, near Hull. In one quite common type of water-softening machine the water is mixed with the proper quantity of chemicals, common slaked lime and soda ash frequently being used, and the mixture is permitted to stand in large tanks by the side of the track until the solid hardening matter thrown out of the solution by the chemicals settles. The clear, softened water is then drawn off through a suction pipe attached to a float, and stored in a supply tank. After weeks of use it becomes necessary to remove the precipitate solid matter from the reservoirs, and this is accomplished by diluting it with hard water, and permitting the mixture to run off through a wastepipe in the bottom. The cost of operating the plants depends largely upon the amount of chemicals necessary, which in turn depends upon the character of the impurities in the water. Even where the water does not contain scale-forming or corrosive impurities, it has been found conducive to longevity and good work in a locomotive to subject the water to chemical treatment.

The Kennicott Water Softener. The accompanying photograph [67] shows the Kennicott water-softening plant at Severn Tunnel Junction on the Great Western Railway, which treats 30,000 gallons per hour. One man in half a day can give all the attention that is needed for a perfect operation of a softener with a capacity of 10,000 gallons per hour. The chemical reagents are hoisted automatically to the top of the machine, where are found the necessary receptacles for dissolving them and the apparatus for automatically varying them in proportion to the quantity of water entering the apparatus. Surmounting the cylindrical steel tank is the water-wheel, over which the hard water is first pumped on its way into the softener. The possibilities for economies that exist in the use of the water-softening system for removing the scale-forming impurities from the boiler-feed water are almost beyond comprehension. The time for imperfect and incomplete methods, such as by using "boiler compounds" in any form, or by employing any treatment wherein the precipitation of the scale-forming solids is not accomplished and the material removed from the water before the water is delivered to the locomotive tender, has passed.



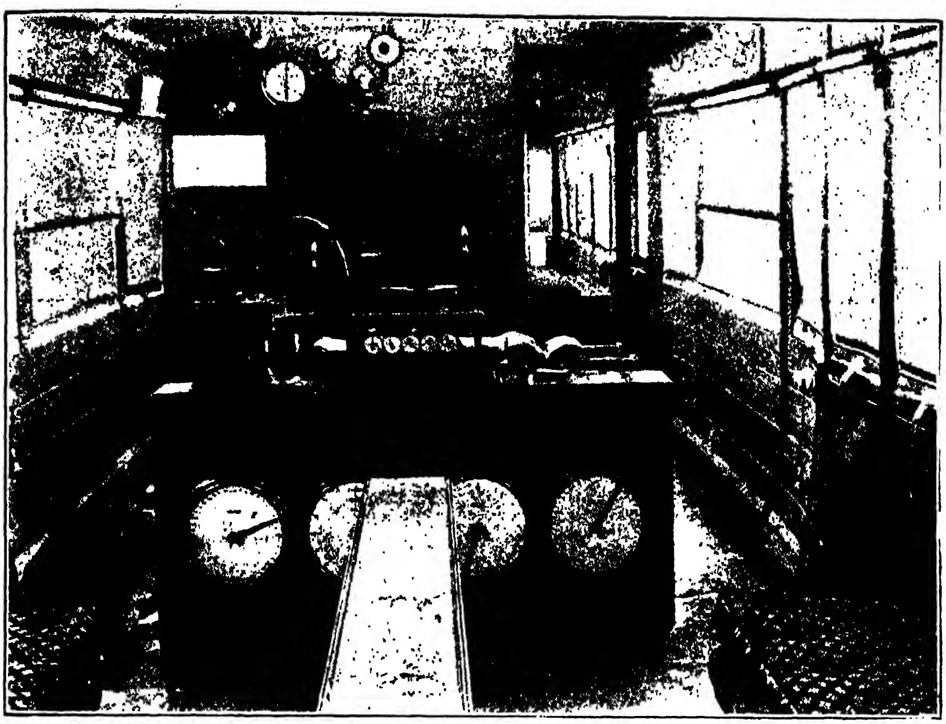
67. WATER SOFTENER AT SEVERN JUNCTION

Dynamometer Car Tests. In order to ascertain the tractive force exerted by a locomotive, several railway companies—namely, the London and North-Western, Great Western, and Lancashire and Yorkshire—employ a dynamometer car [68], which is a long saloon coach replete with a number of complex and ingenious recording apparatus.

The indicated horse-power of a steam locomotive signifies the work done in the cylinders or the maximum effort in propelling the locomotive itself and overcoming friction. But by means of a dynamometer car the engineer is informed what amount of power is available for hauling a given load, inasmuch as the actual work being accomplished by the locomotive is then indicated by the pull on the drawbar, coupled with the rate of speed. Thus valuable comparative data for testing the relative efficiency of locomotives are arrived at.

Dynamometer Apparatus. In the centre of the car is a specially constructed spring, free from friction. To this spring the drawbar of the car is attached, and in making a test the car is placed immediately behind the locomotive, where the stronger the force of the pull exerted by the locomotive the more the spring of the drawbar is deflected. The centre of the spring is coupled to a bracket, to which a sliding rod carrying a stylographic pen is attached. A similar pen is fastened to a small fixed bracket. When there is no pull on the drawbar, the two pens are in alignment, but when the locomotive is exerting a pull, the former pen is drawn away from the latter. The pens make contact with paper, after the manner of those fitted to self-recording barometers. The paper to furnish the impression of a chart rotates on drums, and so is wound across a table, according to one or other of two scales—namely, 1 ft. of paper to 1 mile on the line, or 2 ft. of paper to 1 mile on the line. An additional flangeless wheel, which can be raised or lowered at will so as to engage with the rail, drives the foregoing, together with all other rotating machinery in the car. Accordingly, while a test is in progress, the paper is recording the impression of two inked lines. The line drawn by the pen attached to the fixed bracket is perfectly straight, and is known as the datum line, while that drawn by the pen in connection with the drawbar spring is wave-like. The constantly varying distance between these two parallel lines is measured with a special rule, which gives the force of the pull on the drawbar itself in tons and decimal parts of a ton.

It is next necessary to ascertain the rate of speed at which the tractive effort is being accomplished. This can be given approximately by a dial speed indicator, driven off one of the car axles; but to obtain accurate data the apparatus employed is a clock which is in electrical communication with an electromagnet to which another pen is attached. This pen is deflected, and makes serrations in the line that it draws across the paper every two seconds. Every



68. INTERIOR OF DYNAMOMETER CAR

tenth serration is shorter than the others, so that it can be easily identified. By measuring with a suitable scale the distance travelled by the paper between each tenth serration, the exact speed in miles per hour can be read off at once.

The registration on the chart of the locality of the test train is also very necessary. This is effected by means of an electric push connected with another pen. An operator takes up a position at a window, and manipulates the push according to a prearranged code. Thus, one push, which records one tick of the pen on the paper, signifies a quarter-mile post; two pushes, a mile post; three, a station; and four, a tunnel. Again, the working of the locomotive itself is recorded back to the dynamometer car by a similar push in electrical contact with another pen, this push, of course, being operated by an official on the footplate.

Another apparatus, known as an *integrator*, registers the work done by the locomotive in feet-pounds. By dividing the feet-pounds of work performed per minute by 33,000 (33,000 feet-pounds per minute are equivalent to one-horse power), the horse-power given out by the locomotive is at once obtained.

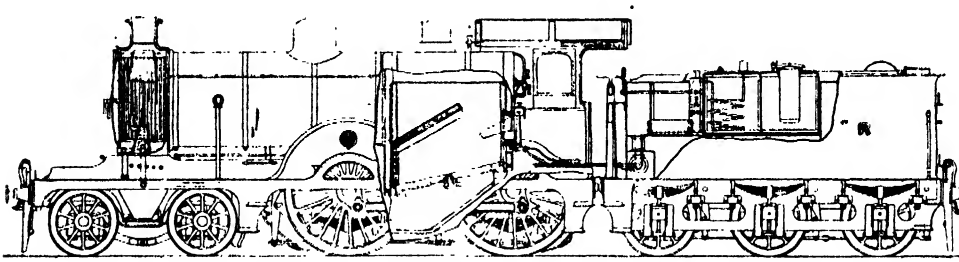
Dynamometer cars are also used for testing the efficiency of brakes. An electrical apparatus is connected up with the last or any coach of the train, and records the exact interval of time that elapses between the application of the brake and its taking effect on the wheels of the vehicle in question. Lastly, some dynamometer cars are equipped with an apparatus whereby the running stability of a coach is ascertained. In the coach to be tested is placed an instrument which may be described as a cast-iron spherical shell containing a cast-iron ball. Rubber tubes connect the shell with an extremely sensitive diaphragm in the dynamometer car, when every movement of the coach, as recorded by the oscillation of the ball within the sphere, is reflected by the impressions of a pen attached to the diaphragm.

Locomotive Stationary Testing Plant. However, even with the employment of a dynamometer car, the practical carrying out of a locomotive test under actual working conditions is beset with difficulties of various kinds, especially the practical impossibility of securing similar conditions on any two occasions. In order to obviate these disadvantages, a very elaborate and costly plant has been devised for testing locomotives in the shop. Very few specimens of this plant are in use, and the Great Western is as yet the only British railway to possess one. The latter is located at the Swindon works, where the employees have nicknamed it the "Home Trainer," in allusion to its functions being cast in the same lines as those of the machine of the name on which professional cyclists practise. The locomotive is run upon the machine, where its driving wheels rest upon rollers of about 4 ft. in diameter which the rotation of the wheels causes to revolve, instead of propelling the engine. The axles upon which these rollers are mounted run in bearings which

are capable of adjustment longitudinally, to suit the different wheel bases of the various classes of locomotives; and the smoke cowl, into which the funnel is inserted, is likewise adjustable. At one end of the machine is a traction dynamometer for measuring the drawbar pull, to which the engine is connected, while the load is put upon the locomotives by means of brakes, which are applied to pulleys upon the axles of the rollers. A locomotive is tested *minus* its tender, but the plant comprises a kind of dummy tender, over the traction dynamometer, from which the locomotive is fired, while the feed pipes are coupled up to a system of water supply, fitted with measuring apparatus.

Placed on the machine, a locomotive may be run at a constant load and speed for as long or short a time as may be desired. By measuring the speed, which can be ascertained by counting the revolutions of the wheels, and the pull exerted at the drawbar, the power given out by the locomotive can be determined at once. The measurement of coal, water, oil, etc., is an easy matter, and as a completely equipped laboratory forms part of the outfit, all manner of practical and exhaustive tests can be applied at the same time to a locomotive submitted for trial. On the Swindon machine, engines have been run at a speed of 70 miles per hour. Nothing of the energy which a locomotive exerts in propelling the road backwards, so to speak, is wasted, as the rollers are connected by driving bands to the shafting of an air-compressing installation.

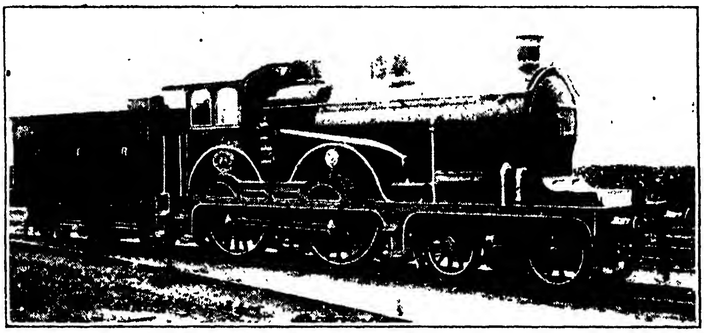
Oil-fired Engines on the Great Eastern Railway. Owing to the rapid development of newly-found petroleum fields, and to the increasing importation of the product, rendering possible a supply of oil fuel at a price which competes with that of steam coal in London and district, the question of the employment of petroleum as locomotive fuel on a large scale in the South of England has of late come much to the fore. The Great Eastern Railway, the pioneer line in this country as regards oil fuel, has had for many years a number of locomotives [70] burning a liquid fuel composed of the waste tar from the compressed oil gas utilised for lighting the passenger carriages. The first experiment with an oil-fuel locomotive was made by the company in 1886, and, proving successful, improvements have continued to be effected in the special apparatus employed, so that at the present day there are about 100 oil-fired locomotives engaged in the suburban, main line, and goods traffic. The system [69] is the invention of Mr. James Holden, the locomotive superintendent of the company, and its novel advantages have secured for it preference even in those districts where oil burning has been the practice for years. It may be said that three elements constitute combustion in the furnace of this class of engine—namely, oil, steam, and hot air. The firebox is provided with the usual brick arch, while almost level with the firebars are fixed two burners which inject the liquid fuel, through apertures, into the firebox. The injecting process is, however, accomplished by means of dry steam from the dome. The two burners receive their steam uniformly, and the liquid fuel fed through them is injected by the force of the steam jet into the firebox, and broken up into very fine spray, which ignites immediately. The use of hot air is to provide air for combustion, in addition to what is admitted through the ordinary dampers. The supply of atmospheric air is drawn from the smoke-box, into which it is admitted through a series of small apertures or one large one, termed *air-inducing rings*. In the smoke-box the air is first heated to a temperature of 400° F. by the waste gases found therein, and then brought to the furnace through air passages provided down the centre of the steam jets. All the pipes conveying the oil, steam, and hot air converge beneath the footplate. The fuel tanks, of course, are in the tender, and for the better adjustment of the supply to the burners, an ingenious arrangement of cocks and valves has been introduced, in order to cut off the oil feed simultaneously with the closing of the regulator, otherwise too rapid generation of steam might ensue. A steam warming coil is placed in each oil tank, so that the liquid fuel may not become frozen in cold weather. Every oil-fired express and goods locomotive carries a few hundredweights of coal, both in order to start a fire on a bed of incandescent fuel and chalk, or broken bricks in the first instance, and to augment the strength of the fire when the train comes to a steep incline or when the engine is called on to make a special effort. The suburban oil-fired engines, on account of the constant stopping and starting, are worked on a system of combined fuels—that is, with a coal fire on the grate and an oil fire burning on a bed of incandescent fuel above it. The relative consumption of the fuels per train mile is in the proportion, approximately, of 1 oil



69. LONGITUDINAL SECTION OF LIQUID FUEL LOCOMOTIVE, G.E.R.

to 2 coal. With an oil-burning locomotive, not a pound of fuel need ever be burned to waste, the firing appliances being exactly adjustable to requirements, whereas with ordinary engines many tons of fuel are consumed in heating air uselessly drawn in while firing is being performed, raising the newly fed fuel to ignition temperature, and generating steam to be blown from the safety valves. An oil-fired locomotive need never make a black smoke; it is, in fact, almost as free from dirt, sparks, and smoke as an electric locomotive. Another important advantage is the increased life assured to the firebox and tubes, owing to their not being exposed to the wearing influence of small cinders and ash, and the destructive effects of sulphurous fumes. Lastly, there is saving of labour to the men in charge. The fireman has no shovelling, no raking the fire; both driver and fireman can remain seated while they manipulate the controlling gear of the engine, together with its fire and boiler feed.

For the storage of the liquid fuel a large depôt has been established at Stratford, together with auxiliary ones at Ipswich and Norwich. It should be added that all the Great Eastern liquid-fuel engines can be immediately converted into ordinary coal-burning ones.


70. G.E.R. LIQUID-FUEL LOCOMOTIVE

Necessity for a Legal Establishment. As railway companies owe their existence to, and conduct the whole of their business under, the provisions of special Acts of Parliament, it stands to reason that they are bound down at every turn by legal restrictions and obligations, any transgression of which renders them liable to suffer pains and penalties. Accordingly, they have constantly to invoke legal assistance to define their rights and protect their interests. Most railway companies have special legal departments of their own, which conduct operations from headquarters. The directors appoint a duly qualified legal practitioner of high standing in the profession to take charge of the department, and provide him with a staff of duly qualified assistants, a managing clerk, and as many ordinary clerks and messengers as may be required. The salaried legal staff, of course, resign their general practices, and devote themselves entirely to the company's interests.

The smaller railway companies employ outside firms of solicitors, and at least one great English company does likewise.

The legal department of a railway company is divided into departments. First, there is the department for Parliamentary work, which carries the Bills promoted by the company for new lines and other works through Parliament. [See page 1237.]

Conveyancing and Common Law. Secondly, there is the conveyancing department. An enormous number of deeds pass through the hands of this office, which examines all titles with the greatest care. The number of title deeds, etc., possessed by any railway company is so great that the general offices are equipped with a fireproof muniment room for their safe custody.

Thirdly, there is the common law or "writ and process" department, which covers wide ground. It deals with innumerable trifling matters in connection with claims, outstanding accounts, demurrage, rates and taxes, damage to luggage, animals, and crops; prosecutes fraudulent travellers, luggage thieves, and trespassers; defends actions brought against the company in connection with personal injuries to passengers; deals with cases of injuries to servants under the "Workmen's Compensation Act" of 1897; and is represented in the highest courts, contesting some such celebrated suit as that of the Taff Vale Railway Company *versus* the Amalgamated Society of Railway Servants.

Liability of Railway Companies. Under Lord Campbell's Act of 1846, railway companies are liable for the negligence of their servants resulting in death or personal injury to any person. An action can be brought for the benefit of the husband or wife, parents, grandparents, children, grandchildren, or stepchildren of the deceased person (but not on behalf of any other relative or person), provided the action be brought within twelve months of the death of the deceased. In any such action, however, actual pecuniary loss must be shown to have been sustained by the persons for whose benefit the action is brought. In an action for personal injury the plaintiff is entitled to recover, not only the pecuniary loss sustained by him by reason of the accident, such as loss of salary or business profits, and any expenses incurred for medical attendance, nursing, etc., but also compensation for losses to be incurred before the plaintiff may have completely recovered, or for any permanent injury he may have sustained. A railway company is responsible, however, only for the negligence or default of its servants within the scope of their legitimate employment. Thus, if a signalman causes an accident by giving a wrong signal the company is liable; but if a porter or

telegraph boy were to mischievously or without authority interfere with the signals and cause an accident, the company would not be liable. Lastly, some accidents are judged to have been "acts of God," and the sufferers have no legal redress.

Qualifications of a Railway Solicitor. The ideal railway solicitor is essentially a railway officer possessing an intimate knowledge of the policy and aims of his company. He must be an experienced conveyancer, for enormous landed interests are entrusted to his keeping, and he must be thoroughly acquainted with parliamentary procedure, together with procedure in the various courts of law and in arbitration cases.

The chief solicitor or his qualified assistants are at all times accessible to officers of every department who may wish advice in relation to their duties, while in all legal questions that crop up in the department, the solicitor has to acknowledge the zealous assistance of officers of other departments.

Every railway company has its own detective and police staff, the uniformed members of which, as a rule, are far from being merely ornamental accessories of the company's service for the purpose of frightening evil-doers and possessing no power to act summarily in the event of detecting an offender. Under their Acts of Incorporation the railway companies were empowered to swear in so many policemen for each station, and some companies—the Great Northern, for example—have obtained later powers which sanction them to swear in as many of their staff as they think fit. The "sworn" men can arrest any person not only on the company's premises, but within a distance of 300 yards of the same.

The Railway "Scotland Yard." The officers of a railway company's detective and police department include a chief superintendent, a chief clerk, and a chief detective inspector, while the staff is composed of detective inspectors, detective sergeants, and uniformed constables. The companies favour recruiting for the department from *inside* the service. It is essential that even the constables should have some experience of the internal working of a railway, inasmuch as the general work of a railway constable differs considerably from that of his civil contemporary, for the former must always be a bit of a detective as well. As to railway detectives, an authority on railway management has laid it down that "a civil detective is of little use in a similar position on the line until he has acquired considerable experience of railway working." The majority of the men composing the "force," therefore, have been originally in the company's service in some other capacity, while the remainder may have been either selected candidates from the Metropolitan, City, or local police, or ordinary private individuals who applied for this kind of employment and were accepted as suitable.

The duties of railway detectives embrace a wide scope. There is the "shadowing" of persons suspected of making bogus claims on the company for personal injuries and loss of luggage, etc., and a most interesting volume could be compiled setting forth the cunning frauds which have been perpetrated, and attempted to be perpetrated, on railway companies on those grounds. Then, the most barefaced spurious claims for loss of luggage are constantly being detected, as, for example, the case of a woman whose alleged lost boxes were discovered to be held by her landlady for unpaid rent. The breaking up of thieving conspiracies hatched by the companies' servants themselves, and the tracking down of well-dressed rascals who frequent the terminal stations for the purpose of snatching jewel-cases, dressing-bags, and other small articles which passengers have left unguarded in the carriages, keep the detective staff busily employed; but, when all is said and done, the detection of ticket frauds forms by far the larger proportion of their duties. Minor offences perpetrated against railway companies are stone-throwing at trains, trespass, and the malicious mutilation of carriage cushions, window straps, blinds, etc.

In all cases of loss or pilferage of luggage, parcels, or goods, the matter is at once referred to the railway police department, which is always in close touch with the civil police. Railway detectives are not, however, privileged to inspect prisoners awaiting trial. Therefore, the chiefs of the departments have a system of exchanging information in regard to the history of suspected persons in custody and of sending their own men to attend trials.

Free Luggage Allowance and some Anomalies. A railway company is bound to carry free with each passenger his personal luggage to an amount fixed by the Acts of Incorporation of the several railway companies, according to the class of carriage in which the passenger travels. This amount varies in different Acts, but, in practice, the railway companies carry free 150 lb., 120 lb., and 100 lb. for first, second, and third class passengers respectively, and the company's liability with respect to passengers' luggage is the same as that with respect to goods entrusted to it for conveyance, so long as the passengers' luggage is under the charge of the company. If, however, the passenger takes the luggage under his own control, the company's liability is diminished, and arises only where negligence is shown on the part of its servants. The question of what constitutes *personal luggage* has been the subject of many judicial decisions; but, broadly speaking, personal luggage may be defined as consisting of such articles as the passenger requires for his own or personal convenience upon or in connection with his journey. Personal luggage does not include merchandise and materials, such as travellers' samples intended for trade purposes: neither are perambulators, sewing machines, bicycles, bathchairs, children's mailcarts, hawkers' handcarts, harps, and street pianos admitted to be personal luggage. All this, of course, is fair enough, but it is not easy to see why certain small articles in every day use, such

as typewriting machines and phonographs should be compelled to pay parcels rates.

The charges for excess luggage are not by any means strictly enforced by British railway companies taken as a whole; and at comparatively few stations is it a rule to weigh luggage before it is labelled.

The Baggage-checking Problem. Strictures are often passed upon British railway companies for their failure to adopt the American and Continental system of the registration of passengers' luggage, meaning that a passenger receives a voucher for his luggage at the departure stations and cannot claim any luggage at his destination station unless he produces that voucher. The registration system has much to recommend it on the score of being a prevention against the loss of luggage by theft or by passengers' mistakenly claiming what is not theirs, but it is wrong to suppose that its non-existence in this country is due to any lack of enterprise on the part of the railway companies. The truth is that the British railway traveller will have none of it, for he prefers running the risk of losing his luggage to incurring the slight delay which the system imposes upon him. In the past, the registration system was given a fair trial by several companies, who abandoned it only on the representations of the passengers themselves.

Luggage in Advance. Again, American visitors regard it as a backward state of affairs that the collection and delivery of passengers' luggage does not find widespread favour in this country. This, too, is due to the idiosyncrasies of British travellers, who prefer that their luggage should accompany them wherever they go, and have little faith in its being delivered by the company in time for their purposes. However, all companies now furnish facilities for the conveyance of passengers' personal luggage in advance that is, collecting at hotel or residence in the principal towns, and forwarding in advance of the owner's journey, and delivery at hotel or residence in the town of destination at a uniform charge of one shilling per package prepaid. Further, the luggage brought by passengers to any of the stations owned by some companies can be forwarded and delivered within the free cartage boundary at the owner's residence or hotel in the principal towns served by the despatching and also other railways, the charge being 6d. per package.

Lost Property and Left Luggage. The system of dealing with lost property and "left luggage" in a company's cloak-room is, as a rule, the charge of one special department as regards control of staff and general working, although the two transactions are conducted in distinct offices. The companies' servants are not allowed to take charge of luggage or other articles left at the station for the convenience of passengers. All such luggage or articles must be deposited in the left-luggage office in the regular manner. Articles of merchandise will not, however, be received at the cloak-rooms, and such packages can be deposited only at the parcels or goods offices. The system observed in a cloak-room is to stack the articles in lots of "singles" (which are generally placed in racks), twos, threes, fours, etc. This renders the work of identification easier when a traveller claims his property.

All unclaimed or lost luggage and other property found in the carriages at or on the platforms of the stations, or upon the line, must be immediately delivered to the person in charge of the station at or nearest to the place where the article has been found. At the expiration of three days all unclaimed or lost property is sent to the headquarters of the company, where it is described and registered, and a copy of the register is sent to the Railway Clearing House daily. The Clearing House, in turn, furnish the information to the different stations, and anything found on hand at a station which answers to the description of an article lost is sent up to the Clearing House for identification.

General Triviality of Unclaimed Articles. The extraordinary conglomeration of articles that find their way into the lost property office and are never claimed has inspired many writers with material for articles on the freaks of human forgetfulness. The machinery employed for tracing the rightful owners has now, however, attained such a pitch of perfection that the companies are burdened with a far less number of articles than formerly, while the articles themselves are mainly of a most humdrum and worthless description. No matter how small or worthless an article, it has a label attached, on which is inscribed the registered number that gives the clue to when, where, and in what circumstances it was found. Nevertheless, there are generally to be seen one or two odd items of lost property. Few lost property offices cannot always boast the possession of several pairs of crutches, which one would think would be the last thing a lame person would be likely to forget.

Every year the unclaimed property of the preceding twelve months is sold by auction. A story that testifies to the rubbishy character of unclaimed property at the present day, is told of an old lady who attended one of these annual sales, imagining that all manner of strange and valuable articles were to be picked up. At the end of the sale she inquired:

"When are they going to sell the things left in the first-class compartments?"

The staff of the cloak-rooms and lost property offices is recruited from the higher grade porters, the men being specially selected for their intelligence and steadiness, while they must also be good penmen, as there is much filling in of forms.

The chief of the left luggage and lost property department is subordinate to the stationmaster. The line is divided into districts, each of which has a sub-department of the kind, but the subchiefs are only responsible to their respective stationmasters.

RAILWAY MANAGEMENT *concluded; followed by* SHIPBUILDING

THE FRENCH REVOLUTION

France Before the Revolution. The Times of Richelieu. The Awakening of the People and the Fate of Monarchy

By JUSTIN McCARTHY

WE must now pause for a time to consider what has, in the meantime, been taking place in Europe.

In France, Henry IV. was succeeded by his son, Louis XIII., who was born on September 27th, 1601, and being only a child, in 1610 his mother, Marie de Medici, was appointed Regent. Marie made an alliance with Spain, and also with the Pope, and betrothed the young King to Anne of Austria, daughter of Philip of Spain, an arrangement which led the Huguenots to rise up in arms against the new policy. A peace, however, was concluded in 1614. The King was subsequently declared of age, and he confirmed the Edict of Nantes, and called together the States-General, which were not summoned again until the reign of Louis XVI.

In 1624 the famous Cardinal Richelieu became Minister of State to King Louis. His first important measure was an alliance with England against Spain, an alliance which was further strengthened by the marriage of the King's sister Henrietta to Charles I. of England. Richelieu endeavoured to suppress the political power of the Huguenots, and his armies crushed many of their strongholds. He entered into many alliances with foreign Powers for the purpose of carrying on a war against Spain, and his religious principles did not always prevent him from making alliances with the Protestants at home and abroad for the purpose of carrying out his political enterprises.

The Rule of Richelieu. The reign of Louis XIII. might well be called the reign of Richelieu. He unquestionably succeeded in weakening and disorganising the power of Spain, and in strengthening and consolidating the power of France, while at the same time he made her merely a powerful despotism, and deprived her of anything like a constitutional system at home. His ambition, however, seems to have been for his State rather than for himself—an ambition to give his country a predominant place in Europe.

There were several conspiracies against him by the great French nobles, the last being that of Cinq-Mars, who joined with the King's brother, Duke Gaston of Orleans, for the murder of the Cardinal. The plot was discovered, and Cinq-Mars was executed. Richelieu died on December 4th, 1642, and Louis survived his great minister only by a few months. He died on May 14th, 1643. His reign was marked by many great wars, principally of Richelieu's making, and he took part in the Thirty Years' War, giving his support to Gustavus Adolphus of Sweden and the Dutch against the Spaniards and Austrians.

Louis XIV. Louis XIV. was born on September 16th, 1638, and succeeded his father in 1643, his mother, Anne of Austria, becoming Regent during his minority. Anne had for her Minister of State the celebrated Cardinal Mazarin, who was born in Italy, studied at Rome and in Spain, and became Papal Nuncio at the Court of France, having already been naturalised as a Frenchman. Mazarin had a powerful influence over the Queen Regent, who is said to have been privately married to him, and through her became a supreme power in the State. When Parliament resisted some of his edicts, he had the leaders of the Opposition arrested, a move which caused the celebrated disturbances of the Fronde, which began in 1648. The Fronde, which took its name from "frondeur," a slinger, caused a civil war, and for a time seemed likely to triumph; but in the end it was suppressed, and Mazarin obtained all his former power over France. He died in 1661, and then the King became absolute ruler of the State. His theory of government he himself expressed in his famous saying, "L'état c'est moi."

Louis was born to be a despot; he had brains, courage, and temper; was dignified and graceful in manners, had unbounded faith in himself, and untiring perseverance. He had capable Ministers, among them Colbert, a great financier, who restored order to the whole financial system of France, which had been coming to ruin under the mismanagement of previous days; and in the many wars which his reign brought about he had some great commanders—Condé, Turenne, Vauban, Luxembourg, Vendome, and others. Louis, who had a passion for conquest and for extending his dominions, was victorious in several parts of the Netherlands, and even Germany. He was becoming, in fact, a terror to Europe, and in his own country he effaced all remains of political independence.

The Queen's Influence. In 1685 he married his mistress, Madame de Maintenon, a woman who with many defects combined many good qualities. Under her influence Louis began a ruthless persecution of the French Protestants, which compelled some of the most intelligent of the French people to seek refuge in foreign countries. The position which he took in the War of the Spanish Succession brought France to the verge of ruin.

The reign of Louis XIV. was adorned by such men as Corneille, Racine, and Molière, and by Fénelon, Bossuet, Boileau, and many others.

Louis XIV. was succeeded on September 1st, 1715, by his great-grandson, Louis XV. The new King was born at Versailles on February 15th, 1710, and the kingdom fell, during his minority, under the government of the Duke of

Orleans, the first Prince of the blood, and his Prime Minister, the infamous Cardinal Dubois. The education of the young King was entrusted to Marshal Villeroi and Cardinal Fleury. The Duke of Orleans had many intellectual gifts, which were marred in private life by his vices, and marred for the public service by his passion for speculation. He was greatly taken by the schemes of John Law, the Scotch financier, who succeeded in persuading the Duke to promote his financial projects. He brought out, in 1719, his famous Mississippi Scheme for reclaiming and settling lands in the Mississippi Valley by means of a joint stock company whose members were to make immense sums of money through the success of the enterprise. The project proved a mere bubble, causing widespread ruin in France.

Cardinal Fleury. After the death of the Regent of Orleans and Cardinal Dubois Louis conducted the government for himself, and put at the head of affairs of State Cardinal Fleury, who did much to improve the condition of the country and to repair the disasters caused by the policy of his predecessors. He exerted his influence to promote peace, but France nevertheless became engaged in many wars. Louis had married, when he was only fifteen, Maria Leszczynski, daughter of the dethroned King of Poland, and through this marriage Louis became involved in the war of the Polish Succession. Many wars also were carried on against England, and also Prussia, although at an earlier date France had been in alliance with that country. During the alliance, while Frederick the Great was ruler of Prussia, France had won victories over the Austrians and the Dutch, and one victory over England at Fontenoy in 1745. England, however, declared war against Louis concerning the boundaries of Nova Scotia, the New World having then become a familiar battleground between rival European Powers anxious for conquest. In this war the English were wholly successful, and became complete masters of Canada, with the result that the Peace of Paris was arranged in 1763. In the next year the banishment of the Jesuits showed that the philosophical party was more powerful in France than the religious one.

Louis XV. was one of the most profligate sovereigns in a profligate age. He was ever under the control of some ruling mistress—Madame de Pompadour at one time, and, later, Madame du Barry, both of whom amassed large fortunes through their Royal lover. Under such rule the Parliament was kept in absolute subjection.

Louis XVI. Louis XV. had exhausted his physical strength by his reckless life, and he died of an attack of smallpox in 1774. He was succeeded by his grandson, the unfortunate Louis XVI., born August 23rd, 1754. He was known as Duc du Berri until the death of his father and elder brothers, when he became the Dauphin. He was fond of hunting and of most exercises, and remained honest and moral in the most corrupt surroundings. He married, on May 10th, 1770, Marie Antoinette, daughter of the Empress Maria Theresa of Austria.

France at this time was like a huge pyramid with the monarch for apex resting on successive layers of nobility and clergy, who alone had any voice in the direction of affairs, the vast bulk of the pyramid being represented by the people, amazingly poor, patient and pathetic, who had no act or part in the governing. All that was required of them was to work hard in order to pay intolerable taxes. Their misery inspired painful reflections in the minds of thinking men in other countries. Lord Chesterfield predicted revolution long before Arthur Young, travelling in France, saw and described a condition of misery which justified revolution and made it inevitable.

The Spirit of Unrest. Revolution was in the air; ardent spirits had long been stirred by the injustice of the existing order of things, and the American Revolution of 1776 gave a purpose to vague impulses with startlingly rapid results. The real France that had lain through the ages in a feudal sleep began to stir uneasily and to stretch for waking. Even the governors saw that the condition of the governed was intolerable, and that they must listen to, if not redress, the grievances of the people. Pressure was brought to bear on the French Government, harassed by lack of funds, to summon a States General, and at length the Monarch and his supporters were compelled to yield. It was so long since it had been held that no one could say confidently what would result from its meeting. Public opinion was divided into the known and the unknown quantity. The known quantity was itself divided into those who held by the old order of things—the Divine right of kings, and the scarcely less Divine right of nobles and prelates to govern France in their own way; and the men and women who had sucked the milk of liberal ideas from the teachings of the Encyclopædists and believed the regeneration of the world was foreshadowed by the American Revolution, and was to be accomplished by an imitation of English parliamentary government. The unknown quantity consisted of the millions whose views on political and social questions it had seemed unnecessary to consider.

The Voice of the People. For the first time the French people found they were allowed to voice their grievances and to choose delegates to represent them. When the unfamiliar elections ended a parliamentary body was in existence of three estates—the first two formed of the nobility and clergy, and the third representing the people in general. These members of the Third Estate came from all parts of France to Versailles, where the States General was held, themselves inexperienced, bearing with them the instructions of their constituents new to any form of parliamentary government. Having a vague belief that the States General would redress all their wrongs, they formulated their griefs very simply and pathetically in papers which still exist, and give the most tragic and truthful picture of France in that day. Their representatives were men of many kinds. Some belonged to the noble order and chose to represent the people's cause. Of these the

greatest was Mirabeau—a man of genius and a lover of liberty who had sinned and suffered much. A large proportion of the Third Estate were ambitious provincial lawyers, pushing their way to Paris and Versailles with great confidence in their eloquence and legislative gifts. Among these was a young lawyer, Maximilien Robespierre, of whom few outside his neighbourhood had heard, who moved inconspicuous among his fellows, a lean and livid nonentity, watching all things with short-sighted eyes.

The National Assembly. The States General began its meetings, and from the first it was obvious that they were to prove momentous. The noble and clerical Estates had hoped to have everything their own way, to mould a submissive Third Estate to their purpose, and get the terms which would fill the empty exchequers of the State and bolster up the Monarchy; then dissolve the States General, send the members of the Third Estates back to their obscurity, and resume the old order of things with money in their purse. This States General met on May 25th, 1789. They soon formed themselves into a National Assembly. Thus the Revolution began. The National Assembly began to make a new constitution, and called themselves the Constituent Assembly. The nobility of the ancient regime were so many that they made a large amount of the whole population, and yet everyone belonging to any grade of nobility was exempt from payment of the Land Tax, or *Taille*; from the *Corvé*, or maintenance of the public roads, from military conscription and the billeting of soldiers, and from other taxes. They had to pay the Capitation Tax, but even in that they were unequally taxed in proportion to the lower classes. Neckar, the famous financier, estimated that the aggregate revenues of the clergy and nobles amounted to 130,000,000 livres. The most oppressive of all the taxes was the *Gabelle*, or tax on salt, while many others unjustly oppressed the Tiers Etât and the people. Louis XVI. and his advisors resisted the reasonable demands of the deputies, and the result was their declaration of inviolability, to which the King retaliated by ordering a large body of troops under arms, dissolving his Ministry, and banishing Neckar, whom he had been compelled by public opinion to recall not long before.

A Nation's Frenzy. An insurrection broke out in Paris on July 12th, accompanied by bloodshed, and on the 13th the National Guard of Paris, a new civic militia under the command of the municipal authorities, was convoked. On the 14th occurred the first great event of the Revolution—the storming and capture, by the people, of the Bastille Prison. The Revolution rapidly spread to the provinces, where National Guards and municipal councils were promptly summoned. On August 4th, feudal and manorial rights were abrogated in a frenzy of renunciation by the Assembly, which solemnly proclaimed the equality of human rights. All the Royal Princes, and as many of the nobility as were able to escape fled from France. The Royal Family also wished to escape, but having failed in all their efforts they professed sympathy with the Republican sentiments of the people in the hope of conciliating them. It was a vain hope; the people were not to be thus placated, and on October 5th of the same year a mob, composed principally of women, marched from Paris to Versailles, and roused the forces of insurrection. The palace was attacked, and the King and the Royal Family, rescued with difficulty from the insurgents, had to move to Paris. The National Assembly also shifted its seat to Paris, and during the next two years it busied itself, somewhat pedantically, with many different constitutional schemes. The Royal Princes and the nobles tried to take arms against this sea of troubles, but the waves of Republican feeling were too strong to be arrested. The King reluctantly made concessions to the Republican party—so many sops to the monster from which he still hoped to escape, but his situation only grew worse.

The Fate of the King. With the death of Mirabeau, who had been trying to advise the Court, all hope for the Monarchy died. The Legislative Assembly, which in 1791 succeeded the Constituent Assembly, suffered from an unwise self-denying ordinance which forbade any member of the former to belong to the latter body. The King was held responsible for the early failures of the war with Austria, which he had been compelled to declare by the Girondist party, and he and his family were in August confined in the Temple. The ineffective Legislative Assembly was dissolved in September, and was followed by the Convention, which included the stronger spirits of the Constituent Assembly. The Convention proclaimed the Republic. In the December of the same year the King was brought to trial for treason against the Republic; he was found guilty, and sentenced to death on January 20th, 1792, and on the next day he was guillotined.

The Reign of Terror. Revolts took place all over the country, and England, Holland, Spain, Naples, and the German States became allied against the Republic. The reign of terror now began. Queen Marie Antoinette was guillotined not long after the King. The Dauphin is believed to have died in prison, though there is some historical doubt on the subject. Marat, one of the most prominent of the "Montagnards," was killed by Charlotte Corday in 1793.

Now the Revolution, like Saturn, began to devour its own children. The Girondists fell before the Dantonists; Danton, Camille Desmoulins, and Hébert were guillotined by Robespierre. Then Robespierre, St. Just, and the other Terrorists were themselves overthrown, and guillotined on July 2nd, 1794. After their deaths came a reaction against bloodshed in favour of peace and order. The insurrections in La Vendeé on behalf of the White Flag occurred in 1793 and 1795, and later on were crushed with great bloodshed. In 1795 a general amnesty was proclaimed; peace was made with Austria-Spain, but the war with Austria was continued. A Directory was now formed to restore peace and order.

Continued

HYDRAULICS

The Importance of Rainfall and Floods in Hydraulic Works. Methods of Calculating River Discharges and Flow. Current Meters

By Professor HENRY ROBINSON

In dealing with this important branch of civil engineering we shall first consider the application of hydraulics to rivers. As rivers convey the rainfall of districts to the sea some part of them necessarily come under the influence of tidal action. They may, therefore, be divided into two classes—namely, tidal rivers and non-tidal rivers. Stevenson (who devoted so much attention to the subject) has stated that all rivers affected by tidal influences may be regarded under three heads—namely:

(1) The sea proper;
(2) The tidal compartment of the river;
(3) The river proper.

These three divisions possess very different physical characteristics—the presence of unimpaired tidal phenomena in the lowest, the modified flow of the tide produced by the inclination of the river bed in the intermediate, and the absence of all tidal influence in the highest. In the lowest reaches of a tidal river the tides resemble those of the sea proper with regard to range of tide and shortness of time between the ebb and the beginning of the flow, and various other factors. As we ascend into the middle division, the range of the tide is less, and the time of ebb and the duration of low water is longer, until we get to the upper division, when the flow is always seawards, and the difference of water level is only that due to the rainfall.

Rainfall. The discharge of rivers depends on the rainfall, evaporation, and the nature of the gathering ground. The fluctuations in discharge depend chiefly on the geology and contour of the ground. The question of rainfall and evaporation have been discussed on page 4024. On impervious gathering grounds with steep gradients the fluctuations in discharge are much greater than on pervious ground with moderate gradients; floods are more violent and draughts are more severe in the former case because, the strata being impermeable, the rain is rapidly carried to the river, causing floods. The rise of the river is more rapid than the fall, because some of the rain is absorbed by the strata, and is returned to the river later. When the strata is permeable the rise is not so rapid, but continues longer, and is therefore more injurious to the adjacent land. In small rivers the flood discharge generally has a higher ratio to the ordinary discharge than in large rivers. This is due to the fact that rainfall is generally more or less local, and is therefore more likely to affect the feeders of a small river than those of a large one, which receives the rainfall from a very wide area.

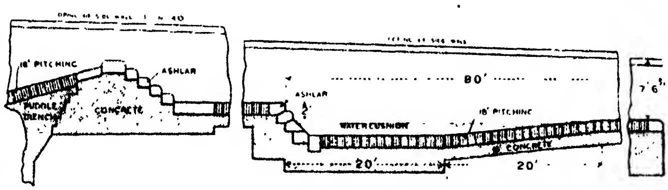
Floods. In our consideration of water supply, the question of floods from gathering grounds was not touched on, as it was thought better to include it under the head of the treatment of rivers, etc., although it has an important bearing on the subject of the construction of works for water supply. Floods are capable of being mitigated by the various forms of river improvement. Data with reference to flood discharge are important for the following among other purposes:

(1) Calculating the lengths of reservoir waste weirs and the sizes of water channels.

(2) Calculating the areas of waterways that are necessary to convey rivers under bridges.

(3) Calculating the areas of waterways, and the heights of floods when "training walls" are to be constructed in rivers.

(4) Calculating the sizes of sluices and the lengths of weirs on canalised rivers.



1. WASTE WEIR AND FLOOD-WATER CHANNEL

Waste weirs are of the first importance with regard to impounding reservoirs, as they serve the purpose of carrying the flood water away from the reservoir, and so prevent the water level being raised above the required height.

It is advisable not to let the depth of the water over these weirs exceed 2 ft. The following allowances per lineal foot of weir are sufficient for this purpose:

3¼ cubic feet per second, with head of 1 ft. above weir.

5¾ cubic feet per second, with head of 1 ft. 6 in. above weir.

8¾ cubic feet per second, with head of 2 ft above weir.

Methods of Calculation. The illustration [1] shows the design adopted by the writer for a waste weir and channel in connection with a large reservoir. The evaporation and absorption by vegetation is a much more constant quantity than the rainfall; consequently the annual discharge fluctuates in a higher ratio than the rainfall, unless the

river is fed very largely from springs that derive their supply from large areas of pervious ground, through which the water has to travel long distances. Volumes of water are usually reckoned in gallons for water supply purposes and in cubic feet for river discharge. Velocities are calculated in feet per second. It is useful, therefore, to have memoranda for converting these several factors into those that are necessary for the various calculations that have to be made.

Memoranda *re* discharge from gathering grounds:

1 acre = 43,560 sq. feet.

1 sq. mile = 640 acres.

1 inch of rain on 1 acre = 3,630 cubic ft. = 22,687 gallons.

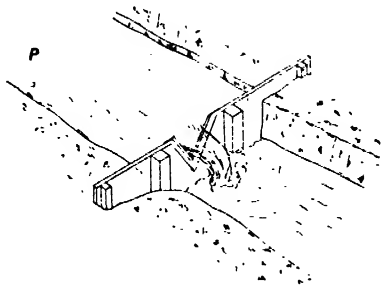
1 inch of rain on 1 sq. mile = 2,323,200 cubic ft. = 14,500,000 gallons (nearly).

1 cubic foot = 6¼ gallons.

∴ cubic feet $\times \frac{50}{8}$ = gallons.

1 in. per annum on 1,000 acres = 62,155 gallons per day.

1 in. per annum on 1 sq. mile = 39,660 gallons per day.



2. "V" NOTCH FOR GAUGING STREAMS

1 in. per annum on 1 acre = 10 cubic ft. per day (nearly).

1 cubic ft. per second = 86,400 cubic ft. per day.

1 cubic ft. per second = 540,000 gallons per day.

1 cubic ft. per second = 197,100,000 gallons per annum.

1 in. of rain per day = 26·889 cubic ft. per second per sq. mile.

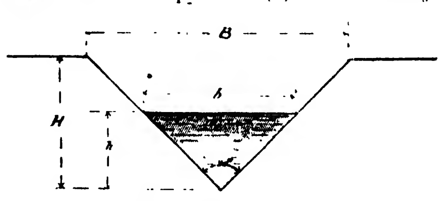
1 in. of rain per day = 0·042014 cubic ft. per second per acre.

1 in. of rain per day = 4·2014 cubic ft. per second per 100 acres.

1 in. of rain per hour = 645·3 cubic ft. per second per sq. mile.

1 in. of rain per hour = 1·008 cubic ft. per second per acre.

Flood Discharges. Some attempts have been made to construct formulæ for flood discharge, but it is impossible to make one of general accuracy. A fairly good formula may be arrived at for a particular district or watershed, but it requires to be modified to meet the circumstances of a totally different district. The table on next page but one records the floods that have occurred on some gathering grounds.



3. DETAIL OF "V" NOTCH

The following formulæ will enable the student to see the way in which a formula for flood discharge can be constructed. The first is that adopted by Fanning to apply to the Eastern States of America, and is as follows:

$$Q = 200\,(M)^{\frac{5}{6}}$$

where M = area in sq. miles,
Q = volume in cubic ft. per second.

The next is Possenti's Formula (modified by Baccarini):

$$Q = \frac{Ca}{S}\left(m + \frac{P}{3}\right)$$

where Q = volume in cubic metres per second,
m = area in sq. kilometres of mountain portion of basin,
P = area of plains in basin,
a = maximum rainfall in 24 hours in metres,
S = total length of watercourse in kilometres.

This formula is intended for Italian rivers.

Data of River Discharges. In dealing with the discharge of rivers, certain data have to be obtained and the following terms are employed:

(1) The *slope* is the fall on the surface of the water, and is generally expressed in feet or inches per mile, and is ascertained by careful levelling.

(2) The *sectional area* (A) is the area of the cross section taken at right angles to the current, usually expressed in square feet.

(3) The *hydraulic mean depth* (R), or *hydraulic radius*, is the result obtained by dividing the sectional area of the channel below the water level (in square feet) by the wetted border or perimeter (P) in lineal feet, the measurements being obtained from the section, and is expressed by $\frac{A}{P}$.

(4) The *mean velocity* (V), which may be either deduced from the surface velocity by formula or ascertained directly by measurement, is used in determining the "discharge."

(5) The *discharge* (Q) is the quantity of water yielded by the river in a given time, generally stated in cubic feet per minute or second, and is obtained by multiplying the mean velocity in feet per minute or second by the sectional area in square feet, and is expressed thus: $Q = V \times A$.

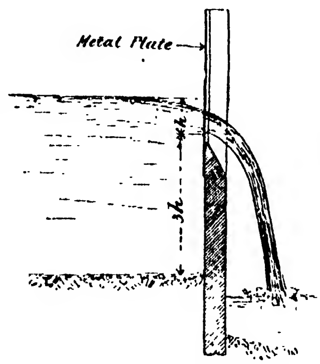
Bridges and Piers. When designing bridges to span rivers, as much width should be allowed between the piers as possible, to keep the channel comparatively shallow. Velocities exceeding 5 ft. per second are liable to cause damage to the foundations of piers, etc., by scour. Some Indian railways are carried on viaducts for miles in crossing large rivers, to provide ample waterway for floods and to allow for deviations in the course of the river through shifting sandbanks. In designing piers care must be taken to obstruct the waterway as little as possible and not to cause avoidable eddies.

The rate of fall of rivers has an important influence on the maximum floods, as steep slopes carry the water off rapidly and do not spread the flood over much longer periods than the heavy rainfall.

Gauging Rivers. In determining the volume of water discharged by a river or stream great care must be taken in order to obtain reliable data. With small streams dams are constructed ; these head back the water, and cause it to flow over a specially prepared weir or notch. The amount passing can then by formula be accurately ascertained. There are several forms of notches, but the "V" notch is more generally used (on account of the greater accuracy obtained), and will be taken for the purpose of this course.

The "V" Notch. The construction of a "V" notch for gauging streams is shown by the illustration [2], of which the following is a description.

Having settled on the best spot to erect the dam, drive stakes firmly into or near the banks on each side of the stream, and fix planks across so as to obstruct the flow of the water.



4. "V" NOTCH IN SECTION

On this dam a metal plate, having a right-angled, or "V" notch [2 and 3] cut in it, is fixed on the up-stream face, and covers a similar but larger notch cut in the timber. The notch in the metal plate forms a sharp edge (the edges of the notch in the wood being chamfered), over which the smallest quantity of water can pass in an unbroken stream. The height of the bottom of the notch from the water level on the down-stream side of the dam must be at least $1\frac{1}{2}$ times that of the head above the notch, in order to allow a perfectly free fall for the water, as shown by **4**.

The dam must be absolutely vertical, and of sufficient height to head back the stream until a pond is formed, the velocity of flow through which is as near zero as possible. The size of the notch is therefore dependent on the above conditions. The height of water passing must be measured from a scale [2P] placed for this purpose in still water, which is generally some few feet from the dam. The reason for this is that the level of the water in the immediate vicinity of the notch is lower than the true head, as shown by **4**. Therefore, under no circumstances must the head be measured from the notch itself. If, however, the width of the dam is considerable, "still" water may be found near the bank, then the scale P [2] can be placed near the dam, and yet be away from the influence of the notch.

Calculation of Water Flow. The formula to be employed in calculating the amount of water passing over a "V" notch is as follows.

When running at any other depth but full, B and H become b and h in the formula. The discharge

$$= Q = C\tfrac{4}{15}B\sqrt{2gH}$$

in right-angled notches.

$$B = 2H \text{ and } Q = C\tfrac{8}{15}\sqrt{2g}H^{\frac{5}{2}} \quad (1);$$

$$\text{if } B = 4H \text{ then } Q = C\tfrac{16}{15}\sqrt{2g}H^{\frac{5}{2}} \quad (2).$$

In right-angled notches with sharp edges $B = 2H$ and $C = 0{\cdot}59$. When $B = 4H$, then $C = 0{\cdot}62$. Taking these coefficients the discharge (Q) in cubic feet per second in Equation (1) becomes $Q = 2{\cdot}54H^{\frac{5}{2}}$; Equation (2) becomes $Q = 5{\cdot}30H^{\frac{5}{2}}$.

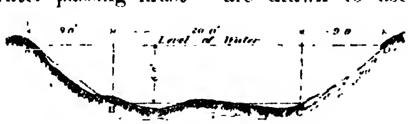
Larger volumes of water flowing in open channels can be gauged by employing a sharp-edged weir. The following formula must then be used:

$$Q = ClH \times \tfrac{2}{3}\sqrt{2gH}$$

where Q = discharge in cubic ft. per second,
l = length (in feet) of weir,
H = head of water in feet,
C = coefficient allowing for contraction.

The coefficient C has been found by experiment to be between ·59 and ·62. This variation depends on the length and head of the weir as well as of the channel of approach. If the depth of water behind the weir is at least 4H, as shown in **4**, and if the channel extends at least 3H beyond the ends of the weir at the level of the sill, the velocity of approach will be insignificant.

Calculating Flow in Large Rivers. In dealing with large rivers, cross-sections of the bed have to be obtained in order to determine the "wetted perimeter" and "the hydraulic mean depth." Cross-sections can be obtained by stretching a line (at a known reduced level) across the river. From this line soundings are taken at regular intervals, and from these the section of the river bed can be plotted. The section having been obtained, equalising lines are drawn to ascertain the wetted perimeter, as shown by **5**.



5. OBTAINING THE WETTED PERIMETER

The slopes A B and C D are found to be $1\frac{1}{2}$ to 1, so that A B and C D $= \sqrt{9^2 + 6^2} = 10{\cdot}8'$, and the wetted perimeter $= 20' + 2(10'{\cdot}8) = 41{\cdot}6'$.

The water surface will be

$$= 20 + 2\ (6' \times 1\tfrac{1}{2} \text{ to } 1) = 38'.$$

The area, therefore, of this section will be

$$\frac{20 + 38}{2} + 6 = 174 \text{ sq. feet,}$$

and the hydraulic mean depth will be

$$\frac{174}{41{\cdot}8} = 4{\cdot}18'.$$

Another method is to take out the area by means of a planimeter.

Ascertaining Velocity of Flow. Having explained how to obtain the sectional area of the river, we proceed to the determination of its velocity in order to obtain the "discharge."

While gauging forms the most accurate method of determining the discharge of rivers, it is necessary for their improvements, or in connection with irrigation canals (in which there is flow), to have some formula which will give an idea as to what velocity may be expected. The formula of Herr Kutter, which is generally adopted, is as follows, expressed in English terms:

$$V = \left\{ \frac{41{\cdot}6 + \dfrac{1{\cdot}811}{N} + \dfrac{0{\cdot}00281}{S}}{1 + \left(41{\cdot}6 + \dfrac{0{\cdot}00281}{S}\right)\dfrac{N}{\sqrt{R}}} \right\} \sqrt{RS}$$

where V = mean velocity in feet per second.
R = hydraulic mean depth.
S = sine of the slope or the fall divided by the length.
N = coefficient of roughness, varying between ·025 and ·035. Rivers with banks in good order and regular, ·025; when in moderate order, ·030; when in bad order ·035.

The velocity of streams varies at different points on the cross-section, being at a maximum near the surface at the centre and at a minimum at the bottom and sides. It thus becomes necessary to obtain the mean velocity for any cross-section in order to determine the discharge. Formulæ have been devised for obtaining this. One of the best has been given, which takes into account the varying roughness of the river bed. Dubuat arrived at the following formula for deducing the mean velocity from that of the surface velocity. If

$$\left.\begin{array}{l} s = \text{surface velocity} \\ b = \text{bottom velocity} \\ m = \text{mean velocity} \end{array}\right\} \text{in inches,}$$

then

$$b = (\sqrt{s} - 1)^2,$$

$$m = \frac{s + b}{2},$$

$$m = \frac{s + (\sqrt{s} - 1)^2}{2},$$

Wheeler gives the following formula as the best for tidal rivers, and it is simpler than the one previously given.

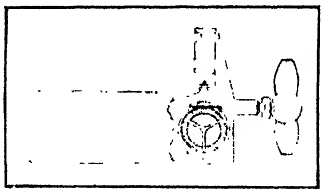
$$V = C\sqrt{2RF}$$

where F = the fall in feet per mile.
R = the hydraulic mean depth in feet.
V = the mean velocity in feet per second.
C = a constant.

Approximately, the constants may be taken as follows: For small streams discharging about 50 cubic ft. a second, 0·65; for larger streams of from 200 to 300 cubic ft. a second, 0·75; for tidal rivers 1,000 cubic ft., 0·85; for tidal rivers 10,000 cubic ft., 0·95; for tidal rivers 100,000, 1·00; for 1,000,000, 1·50.

Current Meters. A better method of arriving at the mean velocity is by means of current meters. The cross-section should be divided up, and readings taken at various points, and at different depths, the number depending on the total depth. The line used for obtaining the lengths for the cross-section will also serve the purpose of fixing the position of the current meters while readings are being taken. One of the points should, of course, be that for ascertaining the surface velocity.

Fig. 6 shows a form of current meter. The velocity of the current revolves the vanes, connected by an endless screw, working in a wheel, which registers the number of revolutions in a given time on a wheel. The motion of water in large channels is so very unsteady that it is not sufficient to take the velocity over only a few seconds, therefore a period of at least one minute should be adopted.



6. CURRENT METER

Another method of obtaining the velocity is by means of floats, sufficiently submerged as not to be affected by wind. The float is dropped into the river, and the time it takes to travel between known points is noted. This method is useful in sluggish streams where the current meter would not work satisfactorily.

For a more detailed study of the subject of hydraulics as applied to rivers, the works of Mr. Stevenson on "River Engineering," and Mr. Wheeler on "Tidal Rivers," may be recommended.

STATISTICS OF FLOODS

	Area in sq. miles.	Cubic feet per second per sq. mile.
Belfast (Trap rock, chalk and greensand). Mean rainfall, 38·42 in.	1·56	34
Manchester (Pennine Chain). Millstone grit, etc.	—	160 to 256 (over ¾ in. per hour)
New York (Croton waterworks)..	20·37	48
Nagpur (Central India)	6·6	170
Ceylon (various irrigation reservoirs)	—	640 (1 in. per hour)
Algeria (irrigation)	312	560
Loch Katrine (Glasgow waterworks)	—	80
River Clyde	—	64
Derwent (above Derwentwater)..	—	About 500

Continued

PRODUCTS OF LAND & SEA

Cotton and Other Fibre Plants. The Meat and Dairy Industries. Animal Products. Fisheries. Sponges and Coral

Continued from page 4962

By Dr. A. J. HERBERTSON, M.A., and F. D. HERBERTSON, B.A.

The Fibre Plants. The temperate fibre plants are flax and hemp [see TEXTILES], with esparto grass, or halfa, in the drier, warmer regions. The warm, temperate, and tropical lands produce cotton, the most important commercial fibre, jute, henequen and the so-called Manila and New Zealand hemps, and China grass or ramie. All these can be spun into threads and woven into cloth of varying degrees of fineness.

Flax. Flax, the oldest of cultivated fibres, is obtained from the *bast* or inner bark of the flax or linen plant. The seeds (linseed) contain a useful oil, and the plant is cultivated in various parts of the world, either for the fibre or the seed, but seldom for both. Its range is great, including both cool, temperate and tropical lands, and both moist and dry regions. When grown for fibre, flax requires much preliminary labour before it is fit for market, which sufficiently explains why other crops are grown in preference. Flax is grown for linseed in the United States and India, and might be grown with advantage for this purpose in this country. Belgium produces the finest fibre, possibly owing to special qualities of the river water. Much foreign flax is therefore sent to Belgium to be *retted*. Russia is the largest producer, followed by Central Europe, Northern Italy, and Northern Ireland. Linen is chiefly used for bed and table linen, and for shirts, cuffs, and collars. It is also made into fine lawns and cambrics, the latter named from Cambrai on the Franco-Belgian coalfield, long a centre of the linen industry. Linen is also manufactured in Ireland, Westphalia, Bohemia, and France. Britain and the United States are the chief consumers.

Hemp and Esparto. Hemp is a coarser fibre furnished by the bast of a species of nettle. It is prepared similarly to flax. The largest quantity is produced in Russia; the finest quality in Italy. Hemp is made into twine, cordage, and canvas, or sailcloth. Great Britain is the chief buyer and manufacturer. [See TEXTILES.] Esparto grass, or halfa, grows in Spain and North Africa. It is used in Spain for making baskets, ropes and matting, and in this country for paper. For the latter purpose it is now largely superseded by wood-pulp.

Cotton. Cotton, the cheapest and most widely-used textile, is obtained from the white woolly fibre which surrounds the cotton plant, of which there are many varieties, or possibly species. The plant is raised from seed, which, in the United States, is planted in April and May, flowers in June, and ripens in August, when picking begins. When ripe, the seed vessel opens, and the cotton tufts expand to about the size of an apple. The picking is not in itself laborious, but, being performed under a hot sun in sub-tropical latitudes, it is exhausting for white men.

Cotton is rather a sub-tropical than a tropical plant. It is grown in India, and other tropical lands, but generally at a considerable height above the sea. In the United States it is grown as far north as 38° N., and in Russian Central Asia (Khiva) up to 43° N. It is very sensitive to frost, and requires a high and fairly uniform temperature (over 70° in Egypt) from April to September, and abundant though not excessive rain. The presence of lime in the soil seems to be an advantage, and some varieties prefer sea air.

The Sources of Cotton. At the present day the United States leads in the production of cotton, Texas being the chief state. The cotton exporting ports are Galveston, which handles the crop of Texas, where the season is early, New Orleans, Mobile, Charleston, Savannah, and others, into whose wharves thousands of bales pour daily as the season advances. Egypt will soon rank next. In India cotton is grown in the Punjab and Bengal, in Gujerat, on the Deccan tableland, in South India, and in parts of Burma and in the north of Ceylon. China and Japan both grow cotton and import it to a considerable extent. Cotton is also grown in the Malay Peninsula, Borneo, the Philippines, New Guinea, and tropical Australia. In Africa it is grown along the east coast of the Mediterranean, in British East Africa, British Central Africa, Madagascar, and along the west coast of Africa. In the New World, outside the United States, it is grown in Mexico, Central America, the West Indies, and in most of the countries of South America north of 30° S., though not on a great scale.

The History of Cotton Manufacture. In the middle of the eighteenth century cotton was manufactured by hand on a great scale in India, and on a small scale in Europe. At the end of that century the mechanical inventions and the application of steam placed Britain at the head of the manufacturing nations of the world and ruined the Indian industry. Seven-tenths of the Lancashire cotton then came from the West Indies, two-tenths from the Mediterranean lands, and nearly all the rest from Brazil. As late as 1792 the United States agreed to export none to this country. The American Civil War, however, led to the shrinkage of the world's supply of raw cotton and manufactured cotton goods, and to the rapid development of cotton cultivation in India and Egypt. New changes are imminent. The southern United States now manufacture cotton as well as the

north and much of the lessened surplus is sent to the Far East. In India the cotton manufacture is also encroaching on the margin for export. Hence the needs of Lancashire must be supplied elsewhere and a recently formed British Cotton Growing Association aims at developing the resources of Nigeria, the Egyptian Sudan, etc.

Qualities of Fibre Cotton. The quality of cotton varies with soil and locality. The ordinary American, or upland cotton, has a short fibre, about 1 in. long, used for all the familiar cotton goods. The low islands off the coast of Georgia and South Carolina grow sea island cotton, with a strong fine fibre 2 in. long or more. This sells at a high price, and is used for thread, lace, and fine stuffs. Peruvian cotton is also long, and is used in hosiery and underwear, in combination with wool. An exceptionally long fibre, grown in the Piura Valley (Peru), fetches a very high price, and is used for hosiery, and for lining rubber tyres. Indian cotton, even when grown from American seed, is short, and does not spin a fine yarn. Egyptian cotton is long, fine, and very prolific, the yield per acre exceeding that of the United States. It is used in making thread and fine underwear.

In the cotton manufacture Britain still leads the world with 47,900,000 spindles in 1903, against 33,000,000 in 1870. The Continent of Europe has 33,000,000, Germany and Russia having 8,000,000 spindles in 1903, against 3,000,000 and 2,000,000 respectively in 1870. The United States had over 22,000,000 spindles against 7,000,000 in 1870, and 19,000,000 in 1900, the rapid increase being largely in the Southern States.

The following table shows the quantity of raw cotton imported by the leading countries at the beginning of the twentieth century:

Country	1,000 cwts.	Value in £1,000
United Kingdom ..	13,849	36,457
Germany	4,393	13,520
France	3,489	8,477
Russia	3,319	6,319
Japan	2,865	6,668
Austria-Hungary ..	2,693	6,028
Italy	2,554	6,017
Spain	1,506	2,933
Belgium	739	1,634
Canada	508	880
Switzerland	458	1,279

Other Fibres. *Manila hemp* is a long, strong fibre, obtained from the leaves of a plant of the banana family. The longest fibres are made into ropes, the shorter into carpets, sail-cloth, etc. Practically the whole supply comes from the Philippines, and is imported through Manila. *Jute* is grown in the delta of the Ganges, and yields a strong, coarse fibre, which became an import article of commerce when the Crimean War (1854-1856) cut off the Russian supplies of flax and hemp. Jute takes brilliant but not lasting dyes, and is largely used in Dundee and elsewhere as a substitute for wool in carpets, rugs, tapestries, and other fabrics. Round Calcutta it is extensively made into gunny cloth for packing bales and gunny sacks, imported into the United States, Brazil, Argentina, etc. Large numbers of jute sacks are also made by Chinese labour in California for the Pacific wheat harvest. *Sisal hemp*, or *henequen*, is used for cordage, sacking, etc. It is obtained from a species of agave largely cultivated in Yucatan and also in British Honduras and the West Indies. *Ramie rhea*, or *China grass*, obtained from a species of nettle grown chiefly in China, India, and Japan, is a fibre much stronger than hemp, and almost as lustrous as silk. It is increasingly used in France, not only for cordage and ammunition bags, but for fine fabrics, table linen, rugs, upholstery, etc. The Bank of France uses it for making banknotes. *Phormium*, or *New Zealand hemp*, is used for cordage. *Coir*, the husk fibre of the coco-nut, is exported from India and tropical America for making coco-nut matting. *Piassava*, obtained from the stem of a species of palm, comes from Brazil, and is made into brushes and brooms. The midrib of the sheaves of the screw pine, grown in tropical America, is made into Panama hats in Ecuador, Venezuela, and Colombia, but many inferior fibres are used as substitutes. Plaiting straw, the stem of spring wheat, very thickly sewn in a limy soil, which bleaches it, is made into hats in Italy and Belgium.

Paper. Most of these fibres are more or less fit for making paper [see APPLIED CHEMISTRY]. Linen and cotton rags have long been pulped for this purpose. Worn ropes are pulped for making brown paper. To meet the enormous demand, esparto has been largely used, as well as others of the fibres named. In recent years, however, the cheap qualities of printing paper are chiefly made from wood-pulp. The fine papers of China and Japan are made from the bark of the paper mulberry. Besides its ordinary uses, paper is used as a material for making boxes, bowls, etc.

Oil Seeds. Some of the fibre plants are also grown for their seeds, from which oil is expressed. *Linseed oil*, expressed from flax seed, is used as a drying medium in paints and varnishes, and in printers' ink, etc. Treated with sulphur and applied to canvas, it is used in making oilcloth. Linoleum is made by a similar process, with the addition of finely powdered cork. Linseed is chiefly exported from India, Russia, Argentina, and the United States. *Cotton-seed oil*, sometimes called *cottolene*, is used as a substitute for butter or lard as well as in making soap. The residuum both of linseed and cotton seed, forms oil cake, used for fattening stock. Other oil seeds are *rape*, largely grown in India and yielding *colza* oil, still used as an illuminant and as a lubricator, though largely replaced by petroleum. *Sesame* is grown in India and Asia Minor, the oil being used both for the table and for lighting. *Poppy-seed oil*, besides its use for food, is imported from India, chiefly to France, for making paints and soap.

No exhaustive list of cultivated plants can be given. In India alone, for a single purpose (tanning and dyeing), 300 species are used. Vegetables dyes are elsewhere less used than formerly. *Indigo*, a blue dye, is exported from Bengal and Madras. *Madder* is grown for yellow

and red dyes in the Levant, France, Germany, and Holland, as well as in India and the United States. Medicinal plants are very numerous. *Rhubarb,* one of the commonest, is grown on a large scale in China.

Products of the Pastoral Lands. The pastoral lands have had an enormous influence on human destiny. The Old World steppes were the home of the horse, ox, camel, sheep, and goat, which man has domesticated, supplying himself with a permanent food supply, the means of transport, and valuable raw materials—wool, hair, hides, tallow, etc.

To rear animals profitably, pasturage must be abundant and land cheap. Animals are bred on a large scale for food or other uses on the thinly-peopled grasslands of the world. In more thickly peopled regions, dairy farming is more profitable. The United States breeds animals chiefly for food (cattle and hogs), as do Canada, Argentina, New Zealand, and Australia. Dairy farming is highly developed in Eastern Canada, the Eastern United States, Denmark, Holland, and Switzerland. Animals are bred chiefly for their hides and tallow in India, Venezuela, Argentina, Russia, and South Africa, and sheep for their wool in Australia, South Africa, Argentina, Western and Central Europe, etc.

The Meat Industry. The western part of the Central Plain of North America is too dry for agriculture. Where there is sufficient buffalo-grass, or other pasture, large ranches, or cattle runs, are formed. The ranching states are Alberta in Canada, and Montana, Wyoming, Colorado, New Mexico, and Texas in the United States. Cattle are also bred in great numbers in the maize belt, where live cattle are fattened for export, as well as in the eastern states. Dressed beef, as it is called, comes chiefly from the ranching states. The animals are slaughtered at one of the meat cities, of which Chicago, Kansas City, and Omaha are the largest, and forwarded in refrigerating cars to the eastern markets, a large proportion being for export. Beef canning, formerly very important, has declined, as the trade in live and dressed beef developed. The great meat packing industry, carried on at Chicago, etc., chiefly handles hogs, which are fattened in enormous numbers in the maize belt. Every part of the hog has its uses. The flesh forms ham or bacon, and is salted, smoked, or canned. Lard, the rendered fat, which forms an ingredient in margarine, candles, etc., is prepared in enormous quantities at Chicago and Cincinnati. The bones are carbonised for use in sugar refining, or made into fertilisers, the smaller bones being used for handles, buttons, etc. The intestines are made into sausage casings, and the tendons, etc., into glue. The hair is used in mixing mortar.

In Canada the dressed beef trade is of little importance, but live cattle are sent to British Columbia and also exported. The meat trade is increasingly important in Argentina. Beef extract is made in large quantities, and Paysandu tinned tongues have a high reputation. Frozen mutton is an important export from Argentina, Buenos Aires having the largest freezing plant in the world. The industry is important in the South Island of New Zealand, and in Australia.

The Dairy Industries. The chief dairy products are butter—which is now made in mechanical separators—cheese, condensed milk, etc. Canada is the largest cheese exporter in the world. The dairy produce of the United States is chiefly for home consumption. Refrigeration is applied to the trade in butter, which is now exported from Siberia and Australia. Denmark and Holland are the chief exporters in Europe. Excellent cheeses are made in Switzerland, Northern Italy, France, and Holland, all exporting countries. Condensed milk is chiefly made in Switzerland. Margarine, made of lard or other animal fats, mixed with butter, milk, etc., is made in Germany, Holland, and the United States. Koumiss, or fermented mares' milk, is an important food among the nomadic peoples of the Old World steppes, and is now recommended as a remedy for consumption. Eggs and poultry may be included with dairy produce. Canada fattens turkeys in large numbers. Much poultry is imported into this country from the Continent. Eggs are imported from France, Austria-Hungary, Italy, and Russia.

Tallow, the rendered fat of sheep and oxen, is exported from the United States, Argentina, Russia, and Australia. It is used in making soap, candles, lubricants, etc. These manufactures are important in the large towns of the pastoral steppes of Russia.

Hides and Leather. Raw hides are imported into this country from India, South Africa, Argentina, Uruguay, Brazil, etc.; tanned hides chiefly from India and the United States [see LEATHER]. The skins are freed from grease, hair, etc., and rendered firm and durable by treatment with astringent substances, generally the bark of some tree, after which it is treated with tallow or other oil to make it supple. Russia leather owes its characteristic odour to the birch bark with which it is tanned. Morocco is a goatskin leather. Chamois leather is made by working oil into the cleaned skin. *Tawing* is a method of treatment with alum to soften leather for the uppers of ladies' boots, and for gloves. The latter industry is brought to perfection in France, Belgium, and Vienna. Kid skin is used for the finest, sheep or lamb skin for the cheaper makes, and calf or dog skin for the stoutest qualities. Leather is also used for saddlery, bookbinding, furniture covering, etc.

Hair. The hide is not the only portion of the skin in use. Horsehair is exported from Russia, Siberia, and Argentina for upholstery. Pigs' bristles are made into brushes. Leipzig is the chief European market, most of the supply coming from Russia. The distinction between wool and hair is difficult to draw. Wool felts, but so do (1) mohair, the silky hair of the Angora goat, a native of Asia Minor and Persia (market, Smyrna), now introduced into Cape Colony and California, (2) the hair of the Kashmir goat, whose scanty yield is extremely costly and is made into the famous Kashmir shawls, and (3) camel's hair, which is exported from China and Russia, and

is used for soft paint-brushes, and for making shawls, etc. Mohair, and the wool or hair of the alpaca, vicuña, and llama, all natives of the Andes, are largely mixed with ordinary wool.

Wool. The finest and softest wool is produced in dry high pastures. The merino sheep, a native of Northern Africa, was early introduced into Spain. Saxony, Silesia, and France effected great improvement in the breed, and the magnificent flocks of Australia are chiefly descended from the improved German breed. Australia (Victoria, New South Wales), produces the finest wool in the world. The mutton of the merino sheep is poor, and the growth of the frozen meat trade is inducing Australian farmers to try various crosses to improve it. The best English breeds are the Lincoln, Cheviot, Leicester, and Southdown. About 80 per cent. of the world's wool is obtained from the merino, from the heavy English sheep, and from crosses between the two.

Qualities of Wool. Wool may be either long or short in staple, and either coarse or fine. The finest and softest wools are generally grown in arid regions, as in Australia and Southern California. That grown in wet lowlands is often coarse and harsh. Worsted yarns are used for merinos, serges, hosiery, carpets, etc. Cloth yarns are made into a great variety of cloths and dress materials. Carpets are everywhere an important product of the pastoral lands. Those of Persia and Turkey have long been famous. They are made of a wool which does not easily felt, so that the pile remains erect. Sheep do well on high hill pastures, and the wool manufacture, utilising the abundant water power, often grew up in the neighbouring valleys. In this country it is still located in the valleys of the Aire and Calder (Leeds, Bradford), of the Tweed (Hawick, Galashiels), and of the Cotswolds (Stroud). The same thing occurred in Saxony and the Ardennes. The manufacture is now important in all the principal countries of Europe, in the United States, and in Canada.

The World's Wool Supply. The world's supply of wool in 1904 was estimated at 2,129,000,000 lb., of which Australia supplied over 24 per cent.; South America over 22 per cent.; Europe over 27 per cent. (the United Kingdom contributing over 6 per cent.); North America over 14 per cent.; and South Africa over 3 per cent. Britain imports over 600,000,000 lb. of wool, principally from her Colonies. Australia supplies two-fifths, London being the great market for Australian wool, though it is increasingly sent to Marseilles, Antwerp, Hamburg, and New York. New Zealand sends a quarter, Cape Colony one-tenth, and British India one-twentieth, in all four-fifths. The following are the figures for 1905:

Imported wool	654,000,000 lb.
Imported sheepskins	24,000,000 ..
Home production	131,000,000 ,,
Woollen rags imported	92,000,000 ,,
	901,000,000 lb.

The last-named are torn into fibres, respun and woven into shoddy and mungo.

Of this total import 279,000,000 lb. of foreign and 35,000,000 lb. of home-grown wool were exported, leaving a surplus of 587,000,000 lb. In addition woollen manufactured goods, valued at £12,600,000 were imported, and woollen goods and yarn to the value of £26,000,000 were exported. The imported wool in 1905 was:

Sheep and lamb	613,700,000 lb.
Alpaca and vicuña	131,500,000 ,,
Mohair	25,300,000 ,,
	770,500,000 lb.

Silk. Silk is produced by the caterpillar of a species of moth, which lays several hundred eggs so minute that one ounce of them will produce 40,000 silkworms, which are hatched. From the good cocoons raw silk is formed; from damaged cocoons, broken threads, etc., silk waste is obtained.

The food of silkworms being the mulberry, lime, and other leaves, they cannot be kept outside the area where these will grow, nor can they be kept all over that area. Cold springs are very injurious. In China, the silkworms are hatched in April, and if the temperature fall below 60°, the yield of silk is much reduced. A second restriction is imposed by the cost of labour. In Italy, girls are employed at a nominal wage to wind the silks off the cocoons, but where labour is highly paid, it is cheaper to import the raw silk than to grow it. For these reasons silk is still chiefly produced in the Old World, especially in China, Japan, India, Persia, Asiatic Turkey, and Italy, the Rhone valley in France, the Adige valley, and the Mediterranean provinces of Austria-Hungary, and to a small degree in Greece and Spain. The silk manufactures of the East have long been famous In Europe, France (Lyons), Germany (Krefeld), Italy (Milan), and Switzerland (Zürich, Basel), are the chief manufacturing countries. In the United States, Paterson, New Jersey, is the "Lyons of the United States."

In China, India, and Mongolia, wild or tussore silk is obtained from other caterpillars or from the mulberry moth in a natural state. Artificial silk is made of cellulose, chiefly from wood pulp.

Other Animal Products. Other important animal products are furs, ivory, feathers, wax, and such commodities as cochineal and lac

Furs are chiefly produced by the animals of the temperate forest. The chief sources of supply are the forests of Siberia, Canada, and Alaska. Of South American furs, *chinchilla* is one of the most popular. Australia exports *kangaroo* and *opossum* furs, and large numbers of *rabbit skins*. *Cats* are bred for their skins in parts of Central Europe. New York and London are the chief markets for North American furs, and Nizhni Novgorod for Siberian furs. The greatest fur market in the world is Leipzig.

Feathers are used both for ornamental and domestic purposes. The former come chiefly from France, the East Indies, and South Africa, famous for ostrich feathers. The principal domestic feathers are those of ordinary poultry, used for bed and pillows, and of the eider duck, obtained from the Polar regions.

Beeswax and *honey* are the product of the honey bee. Both are largely used on the

Continent, the former chiefly for church candles. Wax and honey are exported from Tunisia and Algeria, California, Chile, and New Zealand. Bees are largely kept in Germany, France, Austria-Hungary, and Italy.

Cochineal is a red colouring matter, obtained from the dried bodies of an insect, which is cultivated in Central America and the Canaries, the latter supplying this country. *Lac* is another insect product, used for lacquer, dyeing, etc. The best comes from the valleys of the Ganges and Irawadi. *Ivory* is obtained from the tusks of the elephant, hippopotamus, walrus, etc. Elephant ivory is chiefly obtained from Africa and the East Indies. Hippopotamus ivory is smaller, but is much in demand for the handles of surgical instruments.

Products of the Sea. The most valuable products of the sea are the food-fishes. [See Fisheries in FOOD SUPPLY and NATURAL HISTORY.] The best fishing grounds are the shallow seas, which cover the Continental shelf in the cooler parts of the temperate ocean, and especially the waters of the Atlantic coasts of North America, the Grand Banks of Newfoundland, and the North Sea. The Japanese waters are also rich fishing grounds.

The *cod*, the most valuable fish of temperate waters, is caught by hand lines in vast numbers on the Banks of Newfoundland, chiefly by fishermen from this country, France, Canada, and the United States. A great part of the catch is salted and dried for export to Latin Europe and South America. The fishery is also important in Canadian waters, on the Dogger Banks of the North Sea, and round Norway, especially in the Lofoden Isles. Cod-liver oil, extracted from the liver, is largely exported from Newfoundland and Norway.

The *herring* is caught in the same waters, but nearer the coast. In North America the Maine fisheries are very important, and the small fry are largely canned as *sardines*, the American output competing successfully with that of genuine sardines. Dried, salted, or smoked herrings figure largely in commerce.

The *haddock*, *whiting*, *mackerel*, the *flat fishes* (*turbot*, *sole*, *halibut*), and many others are important in the same waters. The *tunny* fisheries are confined to the Mediterranean, where *sardines* are also important. The best *anchovies* are those of Leghorn.

The *salmon* is abundant in the rivers of Alaska, British Columbia, Norway, Scotland, etc. The canneries of Alaska are now more important than those of either the Columbia or the Fraser rivers.

The *sturgeon* is a large fish, chiefly valued for its roe, which is made into caviar. It is abundant in the rivers of the Black and Caspian seas, in the Great Lakes of North America, and in the Delaware and other rivers. Much so-called Russian caviar is made in Maine, and much from the Delaware is exported to Germany.

The estuaries of the Atlantic coast of North America produce excellent shellfish. The *lobster* is abundant from Labrador to Delaware Bay, but the New England lobster catch has greatly declined, and canned lobsters now come chiefly from Canada. Lobsters are numerous on the Pacific coast, but inferior in quality, in the seas of Northern Europe and the Mediterranean. Chesapeake Bay and Long Island Sound are famous for *oysters*, which are carefully reared. The oysters of our own country have been famous since Roman times.

Whale, Seal, and Dugong Fisheries. The *whale* is hunted for its whalebone, the horny fringe of the upper jaw, and for the blubber under the skin, which yields train oil, used in soap-boiling, and as a lubricant. The fishery is declining. Whales have become scarce, petroleum has largely replaced the train oil, and celluloid, steel, and other substitutes are used instead of whalebone for many purposes. The whale is hunted in Arctic waters, and train oil comes chiefly from Norway and British North America. Peterhead and Dundee are the chief whaling ports in this country. New Zealand is the centre of the whale fishery of the southern hemisphere. The *right*, or *Greenland* whale, found near Greenland, and in the seas north of Norway and Iceland, supplies both whalebone and blubber; the *bottle-nose* whale (from the north-east of Iceland) yields blubber only. The *sperm* whale (hunted near the United States, New Zealand, and in the warmer seas) has no whalebone, but has spermaceti in the head cavity, which is used in making salves and candles. It also yields a morbid product known as *ambergris*, which commands a high price for use in perfumery. It is chiefly obtained from the Bahamas. The *dugong* is caught in the Indian Ocean, the Eastern Archipelago, and the Australian waters. Dugong oil is made in Queensland as a substitute for cod-liver oil. Dugong bacon is a preserved meat exported from Queensland.

The *seal*, an amphibious, fur-bearing animal, is principally capt red on the breeding grounds of the Pribylof Islands in Behring Sea. The pelts are shipped to San Francisco, and thence to London, which is the principal market. *Blubber seals* are captured off Labrador and the Gulf of St. Lawrence.

Miscellaneous Sea Products. The *sponge* comes from the Adriatic and the Eastern Mediterranean. Inferior sponges are obtained from Florida and the Bahamas. [See NATURAL HISTORY.] *Coral*, the skeleton of the coral polyp, is largely manufactured into ornaments round Naples. Most coral comes from the Western Mediterranean, Cape Verde, etc. *Pearl oysters* are obtained by divers from the Persian Gulf, Ceylon, the Sulu Archipelago, Torres Strait, North-West Australia, Tahiti, California, and the northern coast of Venezuela.

Trepang, or sea cucumber, also known as bêche de mer, a kind of sea slug, is obtained round the coasts of the Eastern Archipelago, New Guinea, Northern Australia, and parts of the Pacific. It is in great demand in China and Chinese settlements as a flavouring for soups.

Continued

FLOORCLOTH & LINOLEUM

Materials and Processes in the Manufacture of Floorcloth and Linoleum. Inlaid Linoleum

By W. S. MURPHY

IN our survey of the various branches of the textile industry we have glanced over the history and processes of floorcloth and linoleum manufacture. Necessarily brief, the summary of facts most pertinent to our subject given on pages 1026–27 is quite sufficient as an introduction to our subject. Dealing now with the practical work, we take up the making of floorcloth which is the oldest, simplest, and cheapest of textile floor coverings.

Sizing. In one sense, the making of floorcloth is a finishing process—the covering of a woven canvas with a certain amount of oil paint. The jute canvas which forms the basis of floorcloth is rough and open in texture, and to save paint, as well as to afford the pigment a firm grip on the fibre, we coat the canvas over with a thin size. First the canvas is nailed at full stretch upon large wooden frames provided with screws to regulate the tension in a chamber or stove fitted up with steam heating pipes. Between each frame is a scaffolding upon which the worker ascends to work on the high parts of the canvas. The size is laid on with a brush, the object being to make the cloth as smooth as possible, filling the grain of the rough texture. When fairly dry, but not hard, the surface should be rubbed over with pumicestone and made smooth.

Coating. Before proceeding to lay on the paint we should go over the canvas with the shears, cutting away all the loose fibres and flying threads. The canvas is then ready to receive its first coat of paint on each side. The paint is not the pigment used for coating wood, or other plane surfaces; it is very thick, generally composed of yellow ochre or red oxide of iron, made into a thick paste with drying oil. Lifted on long steel trowels, such as plasterers use, the pigment is laid smoothly on both sides of the sized canvas. A second coat, as soon as the first has dried, is laid on the side to be made the back, while the surface of the other side is smoothed with an application of pumicestone. A second coat is then applied, and after it has dried, the rubbing with pumicestone is repeated. The number of times this is done depends wholly on the quality or thickness of floorcloth desired. After each coating the heating steam is turned on and the doors of the stove shut down. Before applying the surface coat, it should be made certain that all the under coats have thoroughly settled and hardened. Because the surface is to be smooth, the last coat is put on with the brush. The paint is usually of a higher quality than that used for the former coats.

The system of coating described is that employed for high-grade, hand-made floorcloths. The lower grade article more in demand in these days of cheapness is all coated by machine. The rolls of canvas, usually 2 yd. or 4 yd. wide (in the hand-made series we have the advantage of getting goods as wide as 8 yd., thus avoiding cutting and joining in laying large apartments), are passed through a coating machine fitted with colour trough and steel knife, or doctor, which regulates the thickness of the coating, much thinner, of course, than in the case of the hand-made goods. The finishing process of varnishing is also done on a special brushing machine.

Finishing. If the floorcloth is destined for the market in a plain state, it is varnished, seasoned in the drying-room heated up to a temperature from 110° F. to 130° F. Hardened sufficiently, the cloth is trimmed, and wound on to rollers for the warehouse. But if a pattern is to be printed on it the cloth passes unvarnished through another operation, in which it is treated in a way similar to the linoleum. We shall observe both being printed in due course.

Linoleum. Though accepted as a hygienic floor-covering, floorcloth was objected to because of its hardness, coldness, lack of elasticity and deadening property. In order to meet these objections those engaged in the floorcloth business, and others, sought to make another substance, which, possessing all the properties which made floorcloth valuable, would have fewer defects. Linoleum is the most popular result of these efforts. Like the older fabric, linoleum has for its skeleton a layer of jute canvas. The vegetable fibre, however, plays a very small part in the construction of linoleum. Four other kinds of materials make up the bulk of this heavy fabric—linseed oil, cork, kauri gum, and pigments. The linoleum manufacturer has to prepare these materials for his purpose.

Cork. The chief sources of the cork supply of Europe are Spain, Portugal, and Algeria; but, it must be admitted, linoleum manufacturers depend mostly on the cork-cutters for the supply of their needs. Refuse from the great cork-cutting factories is collected and sold to the linoleum trade.

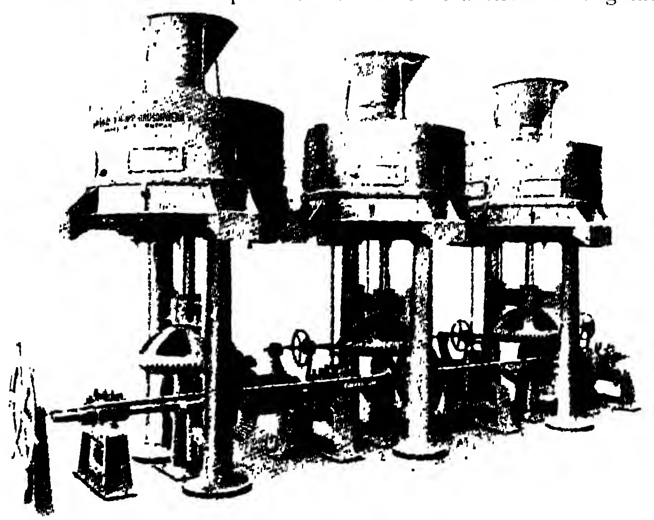
Cork-grinder. To cut cork is rather difficult. It is very tough and elastic. After having been sieved, and thus separated from the rubbish too plentifully mixed with it, the cork is taken to the grinder [231]. Bolted firmly to a driven shaft in the middle of the breaker we find a series of heavy circular saws, one large and one small alternating. Opposed to these are bars of steel, with toothed ends, grooved contrary to the teeth of the saws, and alternating long and short to suit the large and small diameters of their opposites. From a hopper

on the head of the machine, the cork comes down in between the teeth of saws and bars, which speedily reduce it to mingled dust and little pieces.

Milling and Mixing. Though fairly broken the cork is not yet fine enough for our purpose, and it passes on to be ground. This is done in a mill exactly similar to the roller form of flour mill. Between the upper and nether millstones the cork is ground to a fine powder. As it passes through the stones the cork is carried up by a screw elevator to a sieve, through which that which has been properly ground drops into bags while the residue goes back to be ground over again. The sacks which receive the ground cork are designed to contain exactly 56 lb. When full they are taken away to the store, and the cork allowed to dry for a day or two.

Linseed Oil. This is the most important constituent of linoleum. As a rule, new oil is allowed to stand in the tanks and the impurities settle at the bottom.

Boiling. The best and newest method of oil boiling is with jacketed pans. The pan is of copper, circular in shape, and surrounded with an iron steam-jacket up to about half its depth. Both pan and jacket must be able to withstand a pressure of from 36 lb. to 40 lb. per sq. in. In the dome of the pan is a funnel which carries away the vapours of the oil. Within the dome a couple of fans rotate, their wings intersecting each other. A pipe in the lower half of the pan is fitted to admit the air-blast. In the feed tank the oil has been heated by a waste pipe from the steam jacket, and runs into the pan at a temperature of about 95° F. When the steam pressure has reached 32 lb. per sq. in., the driers and the air-blast should be let in. Driers vary, but about 2 per cent. weight of litharge is about the average amount. Keeping a regular pressure of about 32 lb. for four hours, we allow the heat to go down. When cool the oil is pumped into the settling tanks.



231. BATTERY OF CORK-GRINDING MACHINES

First Process of Oxidising. After that part of the drier not absorbed by the oil has settled, the oil is pumped up into tanks on the top floor of the oxidising shed, which is usually placed by itself, and is no higher than is needed for the work. Besides the main tank in the top floor we have little running troughs, with a curious tilt, which makes them give off the oil when it reaches a certain level. These oil distributors run to and fro along the length of the building. Underneath, and stretching up to the rails of the upper floor from the floor beneath, are long webs of thin cotton, called *scrim*. Supported by frames at the top and bottom, these webs receive the oil as it trickles down. Once every twenty-four hours, or oftener in hot weather, the scrim is flooded with oil during a period of from seventy to ninety days. As each layer of oil runs upon the scrim, it is held and solidified. Layer upon layer is piled up in this way till about the thickness of an inch has been obtained, and then the scrim is cut down, affording, perhaps, a skin about 25 ft. long by 6 ft. broad.

Rapid Process of Oxidising. Twelve to fourteen weeks is a long time to wait on a manufacturing process, and linoleum manufacturers naturally sought to reduce the time occupied in oxidising. We can hardly pause to detail all the experiments which were tried, for they were many but the process we are to study is generally admitted to have been successful. The jacketed pan is once more resorted to; but this time with additions. Within the pan are revolving arms that lift up the oil; at the same time a strong blast of air is blown through the pan, acting vigorously on the heated oil. Up to a certain degree, the steam heat is slowly increased, and then, as the oxidising process sets in, the heat is diminished, and the jacket even cooled, by the introduction of water. This process does not give such good results as the older method, though a solidified oil is produced by it in twenty-four hours.

Grinding and Mixing. Whether oxidised by the old method or the new, the oil, now a solid mass, is ground between rollers into a form resembling damp earth, and let cool by spreading on a stone floor. This material is put into a jacketed pan, along with resin and kauri gum, in the proportion of $3\frac{1}{2}$ cwt. ground oil to 1 cwt. resin and 1 cwt. kauri gum. Within the pan is a set of vertical stirrers capable of being driven at considerable speed. When the steam has been put on, the resin is laid in and melted, then the oil and kauri gum are added in small quantities alternately. After the whole of the

ingredients have been put into the pan, the lid is screwed down and the stirrers kept going for from two to four hours. Sufficiently mixed and heated, the mixture is passed through cold grinding rollers into moulding pans, whitewashed inside to keep the stuff from sticking to them. These pans contain 46 lb. of cement, this being the quantity which is needed to mix with the 56-lb. bags of cork.

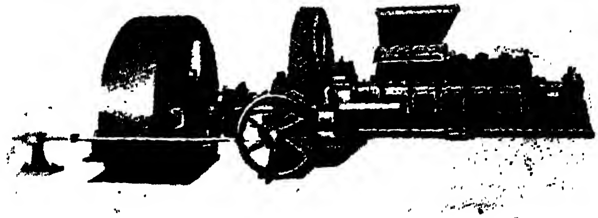
First Mixing. Slightly softened by heat, the cakes are cut up into pieces and fed into the mixing rolls. These are two steam-heated rollers fixed above a third which runs underneath. Into the hopper above the rollers a sack of cork is poured, while a cake of cement is fed in between the rollers. Thus roughly mixed the cork and cement pass on elevators into the next machine.

Second Mixing and Addition of Colour. This mixing machine is a horizontal drum, hung on a spindle equipped with beater arms. On the head of the drum a hopper sits, and into this the mixed cork and cement and the required amount of colouring matter are placed. Given a thousand revolutions or so, the drum is opened by a slide and the material slips down into the next machine.

Third Mixing. With the exception that it is steam heated below, the principle of this machine is the same as that of the cork-cutter. On a horizontal spindle heavy knife-blades are strongly built, and from the sides of the machine come fixed blades, which insert themselves between the revolving knives. From the hopper which communicates with the slide above mentioned, the mixture comes down among the revolving knives. When it emerges from this machine [232] the material bears a strong resemblance to German sausage, and hence the machine is named the sausage machine.

Fourth Mixer. Composed of two rollers, the upper one steam heated within and the lower one kept cool by a stream of water, this machine takes in the sausage, and converts it into thin sheets, which are taken off the lower roller with a knife, named the *doctor*.

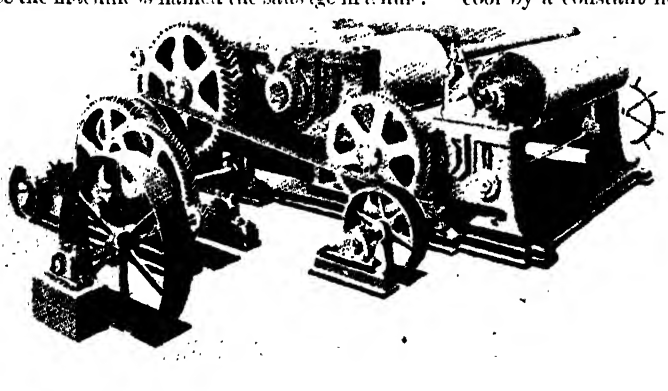
Scratcher. Resembling the above machine in main structure, the scratcher has, instead of the doctor knife, a kind of rude carding cylinder, which scratches the sheeted cement off the cold roller and converts it into the form of little pellets.



232. LINOLEUM MIXER

Making Plain Linoleum. Though simple in construction the machine upon which linoleum is made exhibits high ingenuity. Under a hopper we find an endless web of wire gauze, made to run in the manner of a feed lattice towards a pair of large rollers, which are heated to a temperature of 250° F. Only one of these rollers is heated, the one coming in direct contact with the granulated linoleum. The one over which the canvas passes is not heated, but, of course, contracts a certain temperature from contact with the hot material and the heated roller in front. From a web behind those rollers comes the jute canvas which is to form the fabric of the linoleum. Poured through a hopper over the wire conveyor, the granulated linoleum descends, and meets the canvas in between the two steam-heated rollers [233], which are revolving set to the required distance apart from each other. By the heat and pressure of the rollers the canvas and linoleum are joined. Passing on, the fabric comes into contact with two cold rollers, kept cool by a constant flow of water through them, and is wound on to a beam at the end of the machine.

The contact with the cold rollers has the effect of hardening and polishing the surface of the plain linoleum.



233. FOUR-ROLLER CALENDER

Backing. We have now made linoleum; but it usually goes through yet another process. To render the back impervious to damp it is necessary to cover it with some substance. A backing of strong size was at one time considered sufficient; but now the best classes of the cloth are treated in a machine with a strong mixture, which may be applied either by hand or machine. When the machine is preferred the linoleum is brought

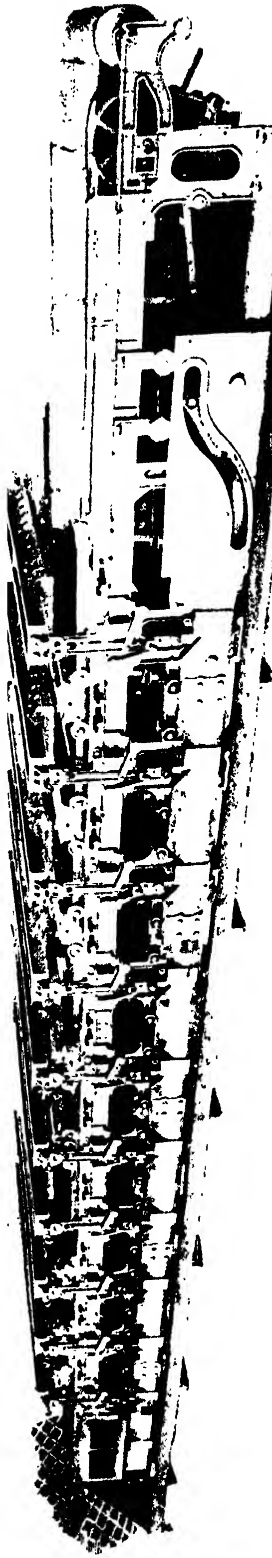
from the roller press and hung on to one end of the machine, which is equipped with backing trough and spreaders. As the linoleum passes through, it receives a coating of the mixture, evenly distributed, and is passed directly into a drying stove opposite the machine.

Seasoning. The seasoning stoves are rooms about 30 ft. from floor to ceiling, heated to a temperature of 110° F. to 130° F., and filled with ranges of hanging battens, upon which the cloths are all suspended in bights or loops.

The batten frames mostly used are like hurdles, with battens slightly convex in shape. Another form now adopted is a horizontal frame of iron, upon which the cloth is drawn along flat by means of ropes and windlasses. The latter form has been considered the superior for plain linoleums and for seasoning cheap printed linoleums, as it is found to prevent the colours from running, but it is not greatly favoured by manufacturers of the higher classes of cloths. The period of seasoning depends wholly on the quality and thickness of the fabric.

Printing Linoleums. The printing of floorcloths and linoleums differs in many details from the printing of other fabrics. The pigment must be laid thickly on the surfaces of the cloths with which we are dealing, whereas the pigment should not be seen on common textiles. This calls for considerable differences in both blocks and methods of printing.

Blocks. Built up of pieces of heavy pine and faced with pear wood, the blocks are either cut out in relief, or studded with copper plates the shape of the pattern. After the shape of the pattern has been cut on the block, it must be lined to take on a large supply of pigment. If a thick surface is desired, the centre of each part of the pattern is hollowed, so as to carry a thick layer of paint. For vari-coloured patterns as many blocks as there are colours must be made in addition to the outline and "smash" block. The blocks for hand printing should be made of a size which can be easily handled.



234. LINOLEUM AND FLOORCLOTH PRINTING MACHINE

Hand Printing. The linoleum printer uses a kind of die press resembling a primitive printing machine. Strong wooden framing holds the printing table and the pressing appliances. From a block of wood held firmly between the supporting standards, the rod which is headed by the spring press blocks comes down. At the head of the rod is the screw; on the foot of the rod is the handle, and below is the pressing block. By a turn of the handle the screw is brought round and the block is pressed down. Beside the printing table the roll of linoleum to be printed is hung, and it is drawn across to the required position. The block has been charged with colour, and it is laid under the press. The printer gives the handle a turn, and down comes the heavy head on the back of the block, firmly impressing the pattern on to the surface of the fabric. By means of gauges in the press the printer is enabled to place his blocks in position with exact accuracy. First the different colours are imprinted, then the smash block is put in to give a level surface and even distribution of pigment; last, the outline block gives clearness of outline to the whole.

Machine Printing. Being such a heavy fabric, linoleum cannot be printed satisfactorily on a cylinder machine, though some attempts have been made; but there was nothing to hinder an ingenious inventor from making the hand press mechanical, and this has been done [234]. Over a long bed, supported on strong framing, the blocks are poised on shafts headed by cam wheels driven by pulleys from the engine. Just above the bed, the colour pads move to and fro, coming forward to paint the blocks as they descend, and retreating in time to let them pass on to the cloth below. Actuated by proper mechanism, and gauged by punches, the cloth comes over the bed and stops at the right moment under each block. The framing and blocks are counterpoised by heavy weights. Constructed on principles so simple, it is obvious that this machine may be extended to any length and take in any number of colours. By the action of the cams the blocks are driven down

on the colour pads and then on the cloth, the balance being regained by the counter weights.

Inlaid Linoleums. For the present we do not pursue the printed fabrics to the finishing rooms, because processes of more importance claim attention. Linoleum is by nature a hard substance; patterns printed on its surface cannot enter into the body of the material; therefore the printing rapidly wears away, and gives sound cloth the appearance of being worn. A remedy for this defect early claimed the close attention of linoleum makers, and various expedients were adopted. Reflecting on the course of operations, one can see that a variation of colour might be obtained in the substance of the fabric if the product of different scratchers producing different colours were taken. Those little pellets have no shape and may be placed so as to make up the body of the fabric with linoleums of different colours. Obvious as the idea seems, it is not easy of execution. Mr. Walton caught the notion and tried to work it out; but the best he could achieve at first was the production of a kind of granite inlaid linoleum. Mixing pellets of different colours, and putting them through the press, he secured, naturally, a fabric of varied colour, but without pattern. The idea proved of value, though the stubborn character of the material gave more trouble in the working out than anyone might expect.

Black and White. The first successful attempt to make a patterned inlaid linoleum was in the production of black and white stripes and squares. Stripes of linoleum, black and white, were formed in a partitioned frame placed in the position of the wire gauze lattice on the rolling machine, and thence run on to canvas in the usual way. The results were good, and different colours were experimented with; but the character of the pattern could hardly be described as artistic. For staircases and narrow passages this form of inlaid linoleum suited very well; but for larger spaces it was quite unsuitable.

Methods of Inlaying. Messrs. Godfrey, Leake, & Lucas invented two methods of forming inlaid linoleum, one being called the *stencil* method, and the other the *grid*. In the first method a thin layer of linoleum is first pressed on the canvas, and the fabric brought round again on to a table. Stencils the form of the pattern are laid over the canvas. Granulated linoleum of the different colours is poured over the openings and pressed in with a scraper. When a sufficient thickness has been laid in, the stencils are removed, and the cloth is passed into the press. The heat and pressure join the whole together.

"Grid." Within a frame or grid, the granulated linoleum is placed. With plunger dies the divisions of the pattern are formed. When the grid is lifted, only those parts which have been moulded by the dies remain in position. The lines thus left open must be filled up, and this is done by another appliance. Iron plates the shapes of the cut patterns are fixed on a wire netting, with the outline spaces between. The netting is placed upon the moulded patterns, and granulated linoleum, driven through the netting, fills up the outlines. The whole is confirmed by heat and pressure.

Sheet Inlaid. Granulated linoleum fails to produce the solid effects desired for many patterns. To retain the artistic freedom which the process gives, and at the same time to obtain a solid pattern, has been the aim of inventors. Mr. Walton and his coadjutors kept to the idea of forming the patterns from the rolled sheet, and advanced along that line by tentative steps. The first advance was simply an improvement of the partitioned frame we have already seen. A cylinder with knives was substituted for the frame, the knives being dies to cut out the shapes of the patterns. Within the cylinder revolved a concentric roller, which, by its motion, ejected the cut patterns from the surface of the roller. The parts thus formed were pressed on to the canvas on a roller press.

Combined Styles. The latest developments of the linoleum trade have taken the form which may be described as a combination of styles. By adopting the thin under-layer of linoleum we obtain the soft effect of the velvet pile. By putting the stencils on cylinders, and working them on the rotary principle, we can use the granulated material and get a flat effect. By reducing the size of the rolled materials to sizes approximating to the size of the granules, the carpet effects desired in high-class linoleum are obtained.

The inlaid linoleums are finished in the same way as floorcloths. Seasoned for the proper period in the seasoning stove, the fabric is rolled on beams suitable for the use of the merchant.

Continued

FUEL & OTHER POWER PRODUCERS

Coal and Wood Fuel. Gas and Oil as Fuel. The Power Value of Solar and Terrestrial Heat. Tidal Power. Zinc as a Power Producer

By F. L. RAWSON

BY far the most common source of power is fuel of one kind or another, most frequently coal, which is used for producing steam in a boiler and thus driving steam engines. Under favourable conditions power can be generated in this way as cheaply as from water power. Coal can also be used in gas producers, the gas being supplied to gas engines, which in recent years have rivalled steam engines in point of size, and, in conjunction with the producing plant, have beaten steam in economy of consumption of coal. Unfortunately the cost of gas-power plant, at any rate in the larger sizes, is greater than that of steam plant of equal power, while its reliability is less.

In countries where wood is plentiful and coal scarce, the former is used as fuel for raising steam, the boilers being provided with specially large furnaces for the purpose. Other combustible vegetable products, such as bagasse (crushed sugar cane from which the syrup has been extracted), are also used as fuel, and in recent years the household and trade refuse of cities has been utilised for power production, being first thoroughly cremated at a temperature of 2,000° F. in "destructors" in order to destroy all organic and noxious substances, and the hot gases being afterwards passed through steam boilers. [See page 5020.]

Gas and Oil as Fuel. In many districts combustible gas is derived from deep bore-holes driven into the crust of the earth, and this can be utilised for raising steam in boilers, or to much better advantage by direct combustion in gas engines. Mineral oils are also obtained in the same way, and are a valuable source of power, the oil being conveniently transported and readily utilised in internal combustion engines very similar to gas engines. As a rule, the oil is either sprayed into the cylinder of the engine, or is first gasified and used as gas. Some engines are adapted for the use of crude or unrefined oil; others for petroleum spirit or "petrol," and the latter are of the type which has come so widely into use for the propulsion of vehicles, launches, etc., of late years. The Diesel engine uses crude oil, not exploded, but burnt in the cylinder in conjunction with a jet of air compressed to a pressure of 800 lb. per sq. in.; the oil consumption amounts to about 0·4 lb. (crude petroleum) per horse-power hour, and the cost inclusive of annual charges on capital to 0·32d. per horse-power hour in an engine of 160-horse power, a very low figure. Oil has also been used for raising steam in boilers, and presents some advantages for this purpose, owing to its small bulk and weight; but if it were generally used in this way its cost would undoubtedly rise considerably on account of the limited supply.

The foregoing sources of power include practically all the agencies generally in use for power production, but there are several others which, though not as yet availed of to any material extent, are nevertheless within the range of practical availability, and which in the future may be utilised to an extent at present undreamed of. Water power and wind power will endure for ever: but coal, gas, and oil, it is believed, will sooner or later be exhausted, or be so difficult of access as to become too costly for use in industry. Then it will be necessary to turn to account those vast and inexhaustible sources of energy represented by the heat of the sun and of the deeper regions of the earth, the tides, the waves of the sea, and even the power that there is in the ether. These at present can be utilised only at prohibitive cost.

The Heat of the Sun. It is estimated that the temperature of the sun's surface is no less than 10,000° C., a temperature of which we can form no adequate conception, the highest temperature with which we are acquainted—that of the electric arc—being only 3,500° C. Of the total amount of heat radiated from the sun, only a minute fraction reaches the earth, and much of this is arrested in its passage through the atmosphere. Observations show that the average amount of heat received from the sun per square foot of the earth's surface per annum would suffice to raise more than two tons of water from the freezing to the boiling point; obviously, however, the bulk of this is received in the equatorial regions, and it is only in places where the sun is nearly overhead, and shines almost uninterruptedly during the daylight hours, that there is much chance of utilising its rays. Assuming these conditions fulfilled, and that the heat received per square foot is double the average for the whole earth, a rough calculation shows that to produce 1,000-horse power during, say, eight hours a day, the heat received over an area of no less than 200,000 sq. ft. must be collected. This can be accomplished only by means of large mirrors, the cost of which would be enormous. Successful results have been obtained on a small scale in America.

As regards terrestrial heat, it is well known that the temperature increases with the depth beneath the surface of the earth, being about boiling point at 3,000 yards. It is conceivable that the huge store of terrestrial heat could be tapped, but the cost and the difficulties would be enormous. The subject was very fully discussed by the Hon. C. A. Parsons in a paper read before the British Association in 1904. The matter is, however, at present beyond the range of practicability.

The Power of the Tides. Turning to tidal power, on the other hand, we find a vast and never-failing fund of energy upon which to draw. There is, indeed, no doubt that the problem could be solved at a cost not unduly inflated, though present conditions do not favour the execution of the extensive works which would be necessary in the first instance. The tides are due to the combined gravitational attraction of the sun and moon—sometimes assisting, sometimes opposing, one another upon the waters of the sea—and the rotational motion of the earth, and vary in range according to the locality under consideration. Thus, in the Bristol Channel the mean range reaches 36 ft., whereas at Wexford, not far away, the range is less than 4½ ft. The fundamental difficulty in utilising the power of the tides lies in obtaining a sufficiently high and constant fall of water. On the average, only half the rise and fall of the tide can be utilised, and that only by the aid of separate high and low water reservoirs, the water being taken either from the outer side or from the high-water reservoirs, and allowed to flow through turbines into either the sea or the low-water reservoirs, according to the state of the tide, so as to give the greatest possible head. Even then, the head would necessarily fluctuate between one tide and the next; moreover, the maximum regular output that could be depended upon would be that obtainable at neap tide. Much greater power could be developed during the spring tides, but it is the steady output that is of importance in industry. If an efficient and not too costly means of storing energy were in existence, this difficulty could be overcome.

The Great Possibilities of Tidal Power. Nevertheless, in spite of the drawbacks pointed out, there are great possibilities in tidal power; it has been estimated that a constant output of 6,800 electrical horse-power could be obtained, for example, from Chichester Harbour by damming up the entrance and dividing the large basin thus formed into two parts; again, there is a powerful tidal flow through the Menai Straits, and by damming the latter at both ends and in the middle no less than 13,500-horse power would, it has been said, become available. But the most fruitful project of all would be that of damming the waters of the Severn in the Bristol Channel, rendering the enormous amount of 240,000 electrical horse power available. The cost of the hydraulic works would of course be very heavy, but the sale of the power developed would suffice to cover the interest and other charges upon the investment. The foregoing are not the only places round our coasts, to say nothing of those in foreign countries, where the tidal flow could be conveniently entrapped and utilised. But such projects must be looked upon only as resources in reserve.

Apart from the regular motions of the tides, it is possible to make use of the less regular motion of the waves of the sea, but not on a scale sufficiently great to be of use for industrial purposes. This source of power has, in fact, been utilised for the purpose of blowing sirens on buoys anchored on dangerous shoals, etc., the rising and falling of the buoy actuating an air compressor within it.

Secondary Sources of Power. The sources of power mentioned above include practically all which can be called natural sources. Various secondary sources are in use, of which we may select two as being of special interest—namely, alcohol and zinc. The former is obtained in great quantities by the distillation of the products of fermentation of vegetable or other organic substances, especially potatoes, which are grown largely for this purpose on the Continent. The manufacture of alcohol requires the use of heat, but as this may be obtained—at any rate, in theory—from a portion of the alcohol produced, we may fairly regard the latter as a secondary natural source of power. The utilisation of alcohol is effected more efficiently in engines of the internal combustion type, such as those used with petrol, than in any other way, and attempts are being made to extend the use of alcohol for driving such engines in order to further the agricultural industries on the Continent. Alcohol is inferior to petrol for this purpose, but not so much as to put it out of court, and it may eventually be widely adopted.

Zinc as a Power Producer. Zinc introduces us to a new mode of utilisation—namely, that of chemical combination (equivalent to combustion) without the evolution of heat. This process may be carried out so as to produce combustible gases, particularly hydrogen; the only use of this gas, however, as a power-producing agent, is in filling balloons, and thus enabling them, by virtue of the low density of the gas, to rise in the air, lifting a considerable weight. But the use which we have more particularly in mind is that of generating electricity in voltaic batteries. It cannot be denied that zinc is an exceedingly expensive fuel. Like alcohol, it requires the expenditure of a large quantity of heat for its preparation from natural sources, and in this case the heat expended is far greater than the energy contained in the zinc produced. Thus, if economical power production were in question, it would be preferable to utilise the heat for this purpose at once, instead of first producing zinc.

But the convenience gained by using zinc to generate electrical currents far outweighs the consideration of cost, and as no other metal meets the requirements of the case to anything like the same extent practically all primary batteries, such as those used for ringing bells, operating telephones and telegraphs on a small scale, and performing many other useful functions, depend upon zinc for their activity. These functions too require but little power for their performance, so that, although the power has really to be paid for at a relatively high price, its cost is negligible, as a rule, in comparison with other items of expense associated therewith. Many attempts have been made to use primary batteries for electric lighting and power, but they have proved commercial failures, though sometimes successful technically.

Continued

Continued from page 5064

SARRUSOPHONES & SAXHORNS

Construction and Parts of the Instruments. Open and Closed Notes. Player's Attitude. Tuning. Scales. Nuances. Exercises

By ALGERNON ROSE

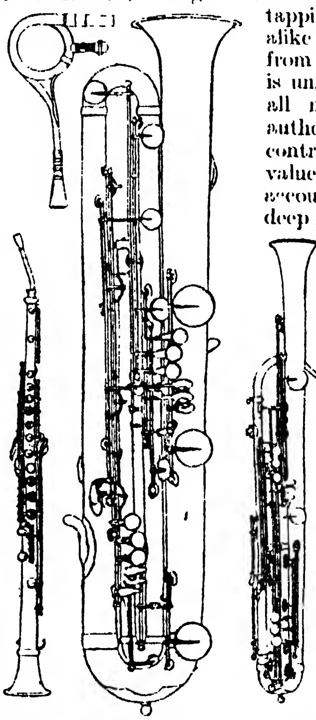
THE SARRUSOPHONE

Although, like the hautboy or bassoon, the mouthpiece of the sarrusophone is furnished with a double reed, its timbre, or character of tone, is quite different. The dissimilarity cannot be described in words, but the sarrusophone, with its body of metal instead of wood, possesses greater sonorousness than the more familiar "wood-wind" instruments.

The instruments, of different sizes and shapes, which constitute the sarrusophone family are chromatic. Beginning at the highest and smallest member, we have the sopranino in E♭, with two-and-a-half octaves compass. The next in size is the soprano B♭ sarrusophone. No. 3 is the alto in E♭; No. 4 is the tenor in B♭; No. 5 is the baritone in E♭; No. 6 is the bass in C; No. 7 is the bass in B♭; No. 8 the contrabass in E♭; No. 9 the contrabass in C, and No. 10 the contrabass in B♭. [See illustration.]

Attitude. To begin with, the student had better take the B♭ soprano. The pose of the body of the player should be natural. Rest the weight on the left foot. Turn the right foot out slightly, and keep it somewhat apart from the left. Hold the head erect. The left hand negotiates the upper joint of the instrument, and the right hand the lower, the right thumb supporting most of the weight by hooking itself under a crook provided for it. Bring the reeds to the mouth rather than the mouth to the reeds.

As far as the *embouchûre* is concerned, the B♭ and E♭ soprano sarrusophones resemble the hautboy, whilst the other members of the family are like the bassoon. On the choice of good reeds greatly depends the quality of the tone which can be produced. Rest the reed on the lower lip. Try to pronounce the syllable "too" by striking the tongue against the tips of the reeds and withdrawing it suddenly [Ex. 3].



Sopranino (E flat) Contrabass SARRUSOPHONES Tenor (B flat)

Tone Production. Try to cultivate a "singing tone." Do not puff out the cheeks, and carefully avoid making a hissing sound, which may come from an escape of the breath at the corners of the mouth through the lips being too slack. No two players being exactly alike, the reeds that will suit one player may not adapt themselves to the mouth of another, although sometimes all they require is a pinch to put them right [Ex. 1].

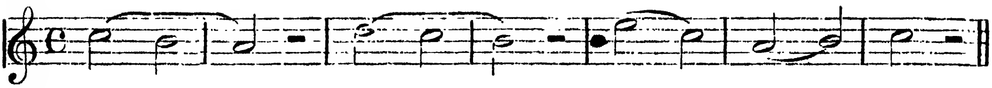
The composer of "Faust" recognised the peculiar cantabile qualities of the sarrusophone in writing a sextet for such instruments entitled "Choral et Musette," in which many astonishing and delightful effects are introduced. But to acquire the singing tone, the first endeavour of the student must be to obtain correctness in articulation. For this purpose, begin with slow pieces, and practise particularly slow scales [Ex. 2].

Rapidity of execution will come in due course. In fingering the instrument, it is waste of effort to raise the digits unduly. The fingers should glide on the keys instead of tapping them. As the fingering is alike for all kinds of sarrusophones, from the smallest to the largest, it is unnecessary to deal separately with all members of this family. An authority has declared that the contrabass sarrusophone is of special value for orchestral colouring on account of its rapid enunciation of deep notes. But, confining our attention to the B♭ soprano, it will be found that the four chief kinds of tone to be produced are notes which are slurred, detached, staccato and portamento. Their methods of articulation are determined by the manner of "tonguing" employed, easily understood by the student who has some knowledge of hautboy, clarionet, or bassoon playing [Ex. 4].

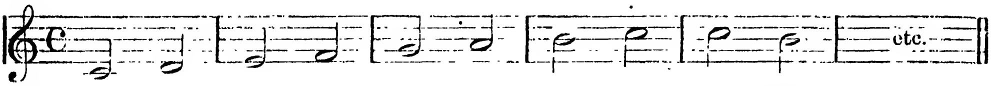
One of the chief charms of the sarrusophone is the control which a good player has over the light and shade, or nuances, of tone, as in the crescendo or the diminuendo. But a matter which requires special care is the artistic management of the breath. In daily practice this should be carefully cultivated. After each phrase the student should refill his lungs, otherwise his breath may give out prematurely and spoil the next passage. [Ex. 5].

Ensemble Playing. From the sopranino to the B♭ contrabass sarrusophone, an extensive compass, chromatic throughout, is furnished by this remarkable musical family.

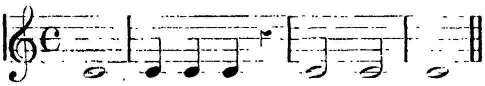
Ex. 1.



Ex. 2.

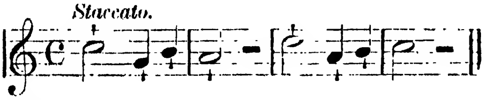


Ex. 3



Ex. 4. *Slurred.*

Staccato.



Ex. 5.

In other words, we have some six octaves, rising from A♭, third ledger line below bass staff, to E♭, third ledger line above treble staff. A complete band, therefore, confined to instruments of this style can easily be constituted. The student who begins with a high sarrusophone and takes to a lower one later on is not confused by either the tenor or the bass clef, the music for all sarrusophones being written in the treble clef. Thus, it is possible to render ten distinct parts with sarrusophones throughout. Owing to the facility of utterance, and the reedy, organ-like quality of tone of such instruments, a body of serious young musicians might well study together a number of contrapuntal pieces by Bach, Handel, or Mozart.

SAXHORNS

The saxhorn family is composed of six or more instruments of different sizes, two of the models—namely, the soprano in F, E♭, or D, and the alto, or contralto, in C or B♭—being held horizontally. The others are held vertically, and include the tenor in F or E♭, also known as the althorn; the baritone in C or B♭; the larger baritone, called euphonium, in C or B♭; the bass, or bombardon, in F or E♭; and, finally, the large contrabass in B♭, which plays the lowest part. The illustrations on the next page show their general appearance, although details of mechanism vary in different makes.

In all these instruments there are usually three valves and pistons. Moreover, whether for treble or bass, music for saxhorn bands is usually printed uniformly in the treble clef. So the beginner, unlike the trombone player, has not the trouble of learning the tenor and bass clefs as well. But perhaps the greatest convenience in teaching such a band is that the fingering of each instrument is almost identical.

Proportions of Different Models. In the formation of purely saxhorn bands, their numerical relations are made up so as to get a fair balance of tone. If we take a band of twenty-two performers, one soprano in E♭ will suffice. No matter how big the band, the penetrating tone of this instrument does not need to be doubled. But the main melody parts will be taken by three first sopranos in D♭, these being supported by two seconds in the same key. The soprano is the smallest saxhorn, and, although played horizontally, the coiling of its tubing differs from the cornet. Next there will be two altos, or contraltos, called also flugelhorns. Then we come to the vertical models with the bell pointing upwards. There will probably be four of the smallest model, called the tenor, or althorn, in E♭.

The richness of tone will then be increased by two baritones in B♭, a somewhat larger type of instrument. These, again, will be supported by the euphonium, or baritone, with extra large bore, in B♭. Then there will be two basses in E♭, one bombardon in B♭, and one contrabass in B♭, playing an octave lower.

Compass. The compass of the smallest instrument is two and a half octaves, from F♯, third ledger line below treble staff, to C, second ledger line above it. The D♭ model goes a tone deeper, although this note, if used, should be indicated in the music as C, below five ledger lines, that being the lowest note possible. The flugelhorn in B♭, with its three pistons down, gives actually E, third space bass clef, although this is indicated as F♯, third ledger line below staff. The tenor in E♭ has a compass from A♯, second space bass clef, written in the music as F♯, third ledger line below treble clef. The baritone in B♭ goes down to E, first ledger line below bass staff, written F♯, three ledger lines below treble staff.

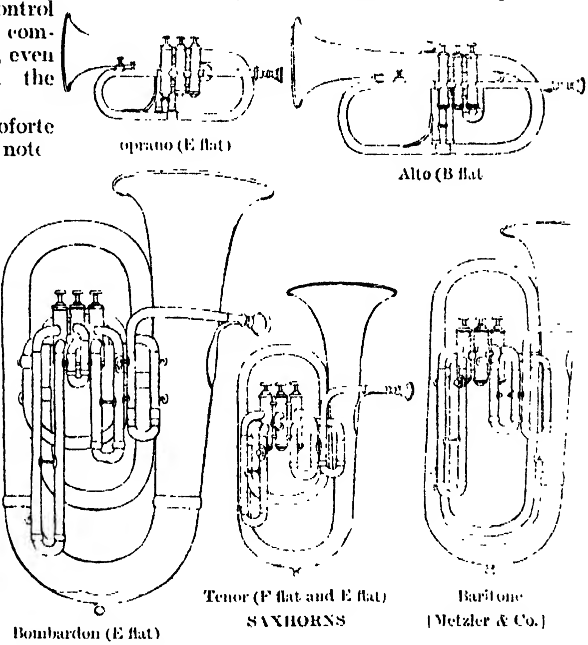
The euphonium in B♭ descends actually to B♭, second ledger line below bass clef, and ascends to three octaves above. The bombardon in E♭ goes down to E♭ below fourth ledger line, bass clef. Reckoning by the length of organ pipes, it will thus be seen that, to get the notes named, the length of tubing in the different models ranges from a little over 3 ft. to nearly 16 ft. in length, and when the contrabass, giving still deeper tones, is considered, further coiling of tubing is necessary.

Position. The soprano, alto, or flugelhorns must be held horizontally, whilst the vertical

models, especially the largest patterns, are canted somewhat to the right for the convenience of the player. Grasp the instrument firmly with the left hand; the right hand must be kept free for the use of the pistons. Sometimes the little finger is placed in the hook provided to keep the saxhorn steady; but this is not recommended by all teachers. Holding the instrument firmly with the left hand, place the first, second, and third fingers respectively a quarter of an inch above the buttons of the three pistons. Rest the thumb under the main tube between the first and second valves. The action of the right fingers must be from the knuckle-joint only. Avoid curving them, but let the fingers move flexibly, quickly, and firmly.

Without blowing, try the following finger exercise, beginning at metronome time M.M = 120, and working up to 208, thus—1 2 3, 3 2 1, 2 1 3, 2 3 1, 1 and 2, 2 and 3, 1 and 3, 1 2 and 3. These are the chief depressions and liftings necessary, and should be done cleanly, without pausing or hurrying. By such movements the fingers and lips of a fairly accomplished euphonium player can control every interval in the compass of five octaves, even when mounted in the saddle.

As in a pianoforte string for the high note the metal is shorter, thinner, and lighter, and for the low bass strings, where immense length is impossible, this is compensated for by extra weight; so, whilst the smallest saxhorn is very portable, the big contrabombardon, by having an increase of bore, is not so long in the tube as, scientifically, it ought to be. Nevertheless, it needs a strong man to play the monster effectively on parade, and when this is done, the deep note very grand.



Soprano (E flat)

Alto (B flat)

Bombardon (E flat)

Tenor (F flat and E flat)

Baritone (Metzler & Co.)

SAXHORNS

The Helicon. These deep-toned instruments are sometimes made circular fashion, to throw the chief weight on to the left shoulder. The player then passes his head through the centre of the coil, and the bell advances over the left. This model is known as the *Helicon*. The shape is martial, but it is doubtful whether the vibration is as free as in the upright model, so much surface being damped by pressure on the shoulder of the player. The effect on the performer himself is no more deafening than it is when the foot of an organist depresses the lowest pedal notes in church. He, therefore, is not the best judge of the disturbance he occasions when he plays a wrong note.

Cleaning the Instrument. If a piston-button sticks, unscrew the cap, take out the pump, and clean it carefully with soft silk. Unscrew the cap at the bottom of the valve and pass the silk through it. Rescrew the valve-cap, and sprinkle a few drops of water—very fine paraffin will last longer—on the pump before replacing it. This should now be found to work freely. If not, a new spring may be required. They cost about 1s. 6d. a dozen. For lubrication of the pumps, never use ordinary oil. Many players polish carefully the outside of an instrument and never attend to its inside. The result is that dirt, allowed to accumulate, deposits itself unequally at the bends. In course of time it perceptibly flattens and throws the instrument out of tune. Once a month a careful player, however, will drive a sponge, dipped in milk, through the tubing. Squeeze it into the end of the mouthpiece, then blow sharply. If the sponge sticks owing to dirt, a leaden bullet, or bullets, will soon force it through. An unclean brass instrument can easily become a bacterial incubator. To a performer who is careless in taking breath, a foul instrument is particularly dangerous. It is a fallacy to believe that keeping one's instrument clean internally will in any way upset its "bearings" or intonation.

Detach the mouthpiece. This the beginner should carry in his pocket to practise upon whenever he is able. The first thing for a student to understand when he takes up any member of the saxhorn family is the correct manner and the principles of blowing. Unlike the reed of a hautboy, the small end of a saxhorn is not put into the mouth. It is placed against the outside of the lips. Here, instead of being beak-shaped, as in the clarionets, the mouthpiece is a small metal cup, ending with a short tube and faced by a flat margin.

Although the biggest saxhorns naturally need a big cup, the manner of blowing is the same for the smallest as for the largest. The internal shape of this bowl has an immense influence over the quality of the tone produced, because the initial vibration of the instrument is generated within the mouthpiece. Even as the funnel-shaped cavity belonging to the French horn produces a peculiar softness of timbre, so a very shallow cup, as in a cavalry trumpet, will give

a hard, brassy effect. For general purposes, a cup of medium depth for each member of the family is best, as it is less tiring to play. If there is much brilliant staccato work in a solo, however, the bandsman will often slip on a shallow-cupped mouthpiece. There being considerable difference in the lips of players, mouthpieces are sold in three sizes. A band of negroes, organised at Mafeking, nevertheless, required a special No. 4 size to fit abnormally large lips. A boy, on the other hand, who takes up a small saxhorn should choose No. 1 size, or he will find difficulty in articulation. To obviate delay in changing this part of the instrument, adjustable mouthpieces can be purchased. By screwing in the rim the cup becomes shallower, and on screwing it out the bowl is deepened. Oval mouthpieces have been tried, but unless adjusted to the lips with great care they spoil the best performance. It is well to have one with a rim of silver, or, at any rate, electro-plated. According to the size of the instrument, silver mouthpieces cost from 3s. to 6s.; electro-plated, the price is from 1s. 10d. to 5s. In brass, the cost is from 11d. to 2s. 6d.; but this metal, if not kept very clean, is poisonous. In cold weather, if the player's lips are cracked, verdigris will cause ulceration, and sometimes serious trouble.

Place the mouthpiece against the centre of the mouth. Two-thirds of the circumference of the rim should cover the upper lip, and the remaining third the lower lip. Hold the stem of the mouthpiece horizontally. The production of tone from any tubular instrument is the result of a series of minute explosions. These, being echoed or reflected within the air passage, are magnified according to its length, so that the longer the tubing the deeper will be the harmonics. It is important, therefore, in the first instance, to set the vibration going correctly. Inflate the lungs moderately. If too large or too small a breath is taken the tone cannot be produced and sustained with ease. At first the student will find that his lip-muscles lack power. By constant practice it is possible to develop them so that eventually he may be able to crack a Brazil nut by his lips without using the teeth.

The Facial Muscles Exercised. Every brass instrument player employs, unconsciously, five sets of facial muscles, and it is well for him to appreciate that fact. First, his playing depends, to a great extent, on the responsiveness of the circular muscle which goes round the opening of the mouth like a broad elastic band, and is known as the *sphincter*. Secondly, he brings into play the elevator of the upper lip, which extends towards the eye. This raises the angle of the mouth and bulges out the cheek below the eye. Thirdly, he uses the depressors of the lower lips, which extend from the mouth downward over the chin, as well as the elevator of the lower lip. Fourthly, he exercises the small muscles which act on the corners of the mouth. Lastly, his playing depends, to a great extent, on the strength of the *buccinator*, or "trumpeter's muscle." This lies inside the cheek, and occupies the interval between the jaws, rising behind the wisdom teeth and extending to each corner of the mouth.

In expelling air from the mouth, as in blowing a saxhorn, the buccinator muscles must be contracted to prevent bulging of the cheeks. Therefore, without inflating the cheeks, press the mouthpiece gently upon the lips, force the breath through them, articulating the syllable "doo." This action causes a quick withdrawal of the tongue-tip, so that the breath is expelled in a thin fluttering sheet, and produces, by the whirling vibration within the cup, a distinct tone.

Tighten the lips still more. Press the mouthpiece harder and articulate the syllable "tee." This, with a little practice, will give an octave sound above the "doo" made with the relaxed lip. The constant varying action of the muscles of the mouth, contracting and expanding at the will of the player, is analogous to that which takes place in the vocal cords when singing. At the same time, it is assisted in a marvellous manner by the excretory ducts, at the root of the tongue inside the cheeks, giving forth the necessary lubrication for the muscles, so that the player is not unduly fatigued.

What is called *tonguing* a note is done by articulating either of the syllables mentioned with extra emphasis. The stroke need not be hard or the tone will be harsh.

The First Tone. The first tone to obtain is that which the instrument gives most easily without touching any of the pistons or buttons. This, in notation, is designated G, second line treble clef. Now, it should be understood that in saxhorn music, where the treble clef is used for all printed parts, exercises for one instrument can be performed with almost equal ease on any other. Thus, C, written third space treble clef, when played on the E♭ saxhorn, sounds automatically not C, but E♭ below, or a sixth lower than the notation. The same C on a B♭ baritone sounds B♭ below, or a ninth lower than the written music.

So, whatever key the instrument is known by, that key gives its root note when the C in the music is played. This simplifies matters for the beginner, although it complicates the task of the composer, since it is he, and not the performer, who does the work of transposition. But if the student wishes to check the first written note, G, by the piano, he must do the transposition for himself. Thus, in an F instrument the G must be checked by C on the piano; in an E♭ instrument the G will agree with B♭; on a D instrument the G will be A; on a B♭ saxhorn the G will be F; and on a C instrument only will the G be G. To obtain the written G, then, close the lips naturally.

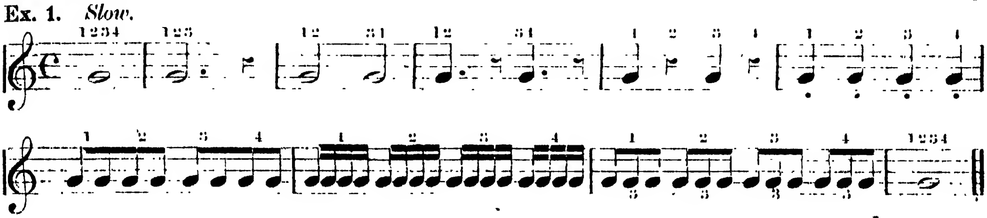
Use very little pressure against the mouthpiece. Blow moderately, pronouncing mentally "doo," withdrawing the tongue quickly so as to sustain the breath and set the long column of air within the tubing into vibration. Although this first attempt may seem a serious operation, the student must not look solemn, for the correct appearance of his lips should be that of the corners of the mouth slightly drawn up, as in

smiling. He must, therefore, bring into play what is known as the ristorial, or laughter, muscle, a narrow bundle of fibres running horizontally from the corner of the mouth to the angle of the lower jaw.

Counting slowly, mentally, try Ex. 1. Having played these ten bars softly, repeat them quicker, with more force, and then with different shades of tone—very soft, soft, moderately loud, loud, and very loud. Practise next increasing the sound, or getting a crescendo in each bar. Afterwards begin as loudly as possible, and diminish the sound in each bar. By such means the first note will be played with confidence and effect.

Harmonic Tones. The saxhorn student will understand that, by the laws of acoustics, every tube of which the vibration is controlled

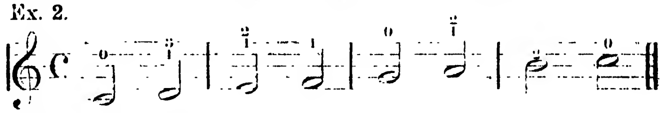
Ex. 1. *Slow.*



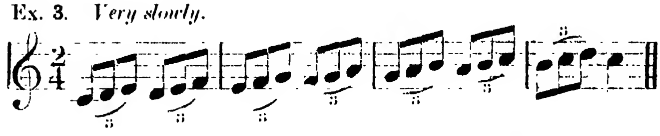
by lip pressure and force of the player's breath gives forth a series of independent tones. In the saxhorn, whether small or large, when none of the valves are depressed, six so-called open notes are articulated, according to the slackness or tightness of the lips and pressure of blowing. These harmonics, which the student should write out in notation, are C, first ledger line below staff, G, C, E, G, and C, ascending from the bottom note, together with their enharmonic equivalents B♯, F×, B♯, D×, F×, and B♯. With the first valve down, thereby opening a further length of tubing, the series becomes a tone lower, so that we have the harmonics B♭, F, B♭, D, F, and B♭, with their enharmonics as before.

Releasing the first valve and putting down the second, the column of air is slightly shortened, with the result that the harmonics now are B♮, F♯, B♮, D♯, F♯, and B♮, with their chromatic synonyms. Depressing the third valve alone, the air-column is extended, and the series becomes A, second ledger line below treble clef, followed by E, A, C♯, and A above, with their musical doubles. The same results are obtained by releasing the third valve and putting down the first and second pistons together. If the second is raised, and the first and third valves are depressed, the harmonics given are low G, with the D, G, B, D, and G above, together with their nominal alternatives. Release the first piston and put down the second and third together. The result will be A♭, E♭, A♭, C♮, E♭, and A♭, with the identical sounds marked by sharps. Finally, open the maximum length of the air-column by depressing all three pistons.

Ex. 2.



Ex. 3. *Very slowly.*



We now get the real open tones, no portion of the entire tubing being closed. The result is low F♯ (or G♭), C♯ (or D♭), F♯ (or G♭), A♯ (or B♭), C♯ (or D♭), and F♯ (or G♭). By tabulating these notes, the student will be able to identify the fingering for any sound in the chromatic scale, from the low G upwards to top C in semitones, by inserting, in ascending the scale, sharps between the whole notes and flats between the same in descending. The numerals 1, 2, 3 always indicate the pistons manipulated by the first, second, and third right fingers, and a zero is the sign used when no pistons are depressed. Thus we have the entire fingering for every usual size of saxhorn.

The Key of C. Before attempting to play the entire scale, the student, except on the bombardon, must accustom himself to blowing the low notes. Get these slowly at first, until, by repeated practice, the lip gradually strengthens itself. In ascending a scale, the pressure of the mouthpiece must be gradually increased, and the lip, at the same time, more and more tightened. In descending the scale, on the contrary, the pressure of the mouthpiece must be gradually lessened, while the muscles of the lips relax themselves in like manner. Apart from the attack of a note by the use of the sylla[illegible] d[illegible] or "tee," with more or less emphasis, the sustaining of the sound by steady blowing to produce a satisfactory tone is of equal importance. This is only acquired by the slow practice of scales, especially, in most models, in the lower register.

Breathing. Another matter for the student to note is the art of taking a fresh breath correctly. This must be done noiselessly, without perceptible movement of the body, and never, if avoidable, in the middle of a slurred phrase. Some players, with abnormal lung capacity, can keep the vibration going much longer than others. Such men are most useful for the big bass tubas. Yet, with exercise, even the narrow-chested student will be able to develop his skill in this respect. Inhaling, when taking a fresh breath, should be done from the corners of the mouth or through the nostrils, and never from the

instrument itself. Endeavour to get the notes in Exercise 2, from the low C to the C above, in good tune.

Descend the octave in the same way. Then construct exercises out of the scale. Play them in correct time, so as to accustom the fingers to depressing and releasing the pistons cleanly. Having articulated each note with a separate breath, bind them together in threes, so that only one tongue-stroke is applied for each group. Do not hurry over this. Take a fresh breath quietly before each triplet, without interfering with the time [Ex. 3].

There are endless ways in which, by transposition, the scale of C major, and other scales, can be practised. Thus, link the first two notes together by articulating on the C and D the dissyllable "too-ee." Then sound the four notes above staccato, articulating "tee" for each one. In descending from the B to the A, link those notes by pronouncing mentally "tee-oo." Then let the tongue strike "tee" for the remaining notes, giving a long "doo" for the final C [Ex. 4.]

Nuances. An easy key, after C, on the saxhorn is F major, with one flat, B. But what is known as light and shade in music requires much practice. The student, therefore, cannot begin too early his exercises in what are known as nuances. Try to get distinctly the octave of sounds in the key of F, from the first space to the F on the fifth line, making a crescendo, and then a decrescendo in one breath on each note, whilst counting mentally two very slow beats [Ex. 5].

When the scale of F has been mastered in this manner, ascending and descending, the student will find no difficulty in playing the "National Anthem" [Ex. 6].

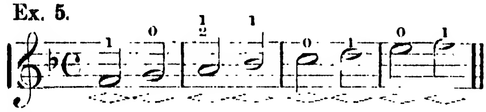
Another key which brings out many beautiful qualities in the various members of the saxhorn family is B♭. In the natural scale of C, the seventh degree is marked by B, which, in German, is designated H, pronounced "Ha," following their A, spoken "Ah." This is equivalent to an Englishman calling the semitone above A "Hay." But this H in the German scale gave one of their greatest musicians an opportunity to compose a beautiful fugue on his own name, "Bach." For this reason alone, the Germans are justified in keeping the letter H in their musical alphabet. So they have no B♭, our B♭ being known as their B. In the military band, B♭ is the key in which most of the clarionets, as well as the larger brass instruments, are pitched. Here we are treating, however, of music written in B♭ rather than the actual notes that are played by transposition. Incidentally, it will be well for the student now to acquaint himself with the abbreviations and rests used frequently by copyists of music parts in brass bands.

Music Copying. Bandsmen frequently fill in their spare time by part-copying. The pay is twopence or threepence per folio, and when speed in penmanship has been acquired, such work is not to be despised. In France, many years ago, the great poet Rousseau kept the "wolf from the door" by such means, and his "Musical Dictionary" has a long article on the subject of music copying. The intelligent student, therefore, when his lips get tired in practising, may find profitable recreation in writing out the exercises for his instrument on music-paper, so that musical caligraphy may, by-and-by, come to him as readily as that used for ordinary correspondence. To avoid the labour of writing the same notes or passages many times, a minim crossed by a single thick line represents four quavers, and a crotchet crossed by two lines equals four semiquavers, and so on; whilst an oblique stroke with a dot on either side of it implies a repetition of the previous bar. In those saxhorns used chiefly for filling in harmonies rather than playing melody parts, the performer may expect to come across a couple of vertical strokes in a bar with, perhaps, the figure 6 over them, or a long horizontal stroke with a 10 above it. Such signs indicate that he must cease playing for as many bars as are specified by the numbers.

Try the scale of B♭ major, tonguing each note four times, and observing the abbreviated signs [Ex. 7]. Now link each note of the scale with the first B♭, so as to get distinctly the successive intervals. Allusion has been made to the

Ex. 4.

Ex. 5.

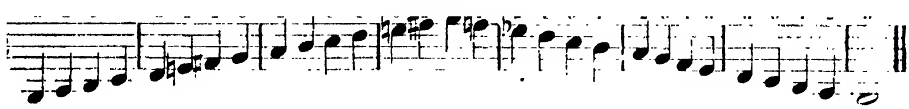


Ex. 6.

Ex. 7.

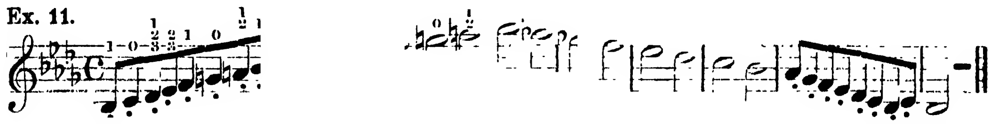
Ex. 8.

Ex. 9.

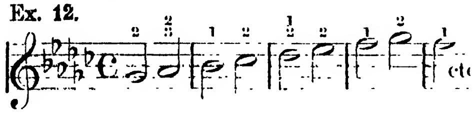


Ex. 10.

Ex. 11.



Ex. 12.



muscles of the mouth which influence the production of the sound on the saxhorn ; but unless a careful appreciation of such sounds is cultivated by the nerves of the ear, although the force of the blowing may be correct, the pitch sounded by the instrument will leave much to be desired. It is the ear of the player which must guide him to the relative distances of height and depth of the tones, so that the sounds may be in good tune. After getting the first B♭ properly, slur the C and D together with a "tee-oo," as already explained.

A whole tone above the C comes the D. Link that with the B♭ by another mental "tee-oo." But the E♭ is only half a tone higher than the D, because the first semitone in a major scale comes between the third and fourth degree, whilst the second semitone occurs between the seventh and eight, and the same in descending. In whatever major key the student is practising, the places of these half-notes must always be borne in mind [Ex. 8].

G Minor. The minor scale which has the same signature as B♭ major begins a minor third lower than the B♭ just played. It is therefore G minor. Try this scale through two octaves. Remember that, in the melodic minor form, the half-tones occur between the second and third and seventh and eighth degrees going up, and the sixth and fifth and third and second coming down [Ex. 9.]

To familiarise his fingers with correct piston manipulation, the student can construct many exercises on this scale. Then, by varying the time, writing the same exercise out in three-four instead of four-four tempo, his playing will be improved profitably. In an illustration we here give, one stroke of the tongue must suffice for every two notes linked together by a slur. In each case, slightly relax the lips for the second note. In violin playing all notes placed under a slur are performed with one bow ; likewise, on the saxhorn, all notes constituting a similar phrase should be articulated by one breath. Yet the student should be careful not to exaggerate the glissando effect [Ex. 10].

B♭ Minor. Having essayed the relative minor of B♭ major, try the key of B♭ minor in its melodic form. This, being the relative minor to D♭ major, has five flats, B, E, A, D, G. By this time the embouchûre of the student should be fairly under control—by embouchûre is meant, not merely the mouthpiece of the saxhorn, but the condition of the lip-muscles and facility in blowing. Without difficulty he should be able, therefore, to obtain, by increased lip-pressure, the higher notes of the second octave. If they demand special exertion it is better not to force them, but to confine practice to the lower octave until this can be played with facility in quick time and in all the different exercises by transposition [Ex. 11.]

Having proceeded from B♭ major to G minor, and thence to B♭ minor, with five flats, try G♭ major, with six flats, which are as many as the student need trouble about in saxhorn playing. This scale is confined to one octave, from G on the second line to G above the staff, low fiddle G, so far as concerns written music, not being within the ordinary saxhorn compass. Here all the notes are flats, excepting F, which is natural. In this key, however, double flats are likely to present themselves. In that case the note so marked is depressed a whole tone. Thus, B♭♭ is played with the same fingering as A♮, E♭♭ in the same manner as D♮, A♭♭ like G♮, and so on. Exercise 12 gives the scale.

Sharp Keys. As much attention must be given to the sharp as to the flat keys. Although G♭ major has six flats, the key of G♮ has one sharp, F. Then come in succession the keys of D, with C as its second sharp ; A, with G as the third sharp ; E, with D as the fourth sharp ; B, with A as the fifth ; and F♯, with E♯ as the sixth. These are no more difficult to learn than flat keys, thanks to the different lengths of tubing—opened up on depression of the pistons—being arranged equally to admit of the

temperament in tuning adopted for the pianoforte. The various saxhorns, indeed, are no more difficult to blow and learn than the cornet, and are equally applicable as regards the fingering, execution of rapid passages, and double or even triple tonguing. To acquire a brilliant and spirited articulation of staccato notes, try the scale of G major with double-tonguing. The action of the tongue is that of pronouncing the dissyllable "too-tle." Different particles of speech are recommended by foreign teachers. For triple-tonguing the usual trisyllable is "too-tle-too." Hence the expression in our language of "tootling" on a wind instrument.

Fingering. In music, the note G, from which G major begins, has always had much significance, for it furnished the "lichanos" of the Greeks, the first note of the aeolian, or church mode, the lowest note of the grave hexachord as of the violin, and gave the letter-name to our treble clef. Consequently many old melodies are written in this key, and, coming to the saxhorn, the student will remember that the first sound elicited was G on the second line. Now get the G, octave below, with the first and third pistons down and a slack lip. With the first and second pistons down, get the A above. With the second down, get the B. Now sound C, half a tone higher, without depressing the fingers. Putting down the first and third, play D. Employ the first and second for E. For the F♯ use the second only. Then sound the open G with the pistons up. Get A with the first and second valves down. Sound B by putting down the second finger only. The open C, half a tone higher, should be easy. Put down the first finger for D. Release this piston for E. Put down the second finger for F♯. Finally, sound the open G, tightening the lips. Return to bottom G in the same manner.

D Major. Next try D major, within a compass of one instead of two octaves. Begin with the D below the staff. For this, put down the first and third pistons. For E, depress the first and second buttons. Put down the second finger for F♯, and then sound the open G above. For A, put down the first and second fingers; for B, the second finger only; and the same for C♯ above. The first finger depressed will give the octave D. Return in the same manner. Still double-tonguing each note, take the scale of A major, with three sharps, through two octaves. For bottom A, put down the first and second fingers. Depress the second finger only for B. For C♯ put down all three pistons. Depress the first and third only for D, and the first and second for E. F♯ is produced by lowering the second piston, and G♯ by putting down the second and third fingers together, whilst the octave A is sounded by means of the first and second.

With increased pressure of the lip, get the B by the second piston, the C♯ by the first and second, and D with the first. E above is an open note. Then comes F♯, produced with the second piston, G♯ by the second and third fingers, and top A by putting down the first and second. Descend the scale in the same way.

E Major. Proceed to E major, with four sharps in its signature, through one octave. Sound E on the first line by lowering the first and second fingers, F♯ by depressing the second, G♯ with the second and third, A by the first and second, B by the second only, C♯ by the first and second, and D♯ by the second only. Top E is an open note. Return in similar fashion. Try B major, with five sharps, through two octaves, beginning with B below first ledger line, putting down the second piston. Triple-tongue each note.

Having executed a "too-tle-too" on B, get the same articulation on C♯, putting down all three pistons. Release the first finger for D♯. Depress the first and second pistons for E, the second only for F♯, the second and third for G♯, the first for A♯, the second for B, first and second for C♯, and the second only for D♯. Release all pistons for E. Put down the second for F♯, gradually tightening the lips. Depress the second and third pistons for G♯, using the first only for A♯, and get top B by putting down the second finger only. Descend the scale in the same way. In saxhorn music the scale of F♯ with six raising signs, is seldom used, its synonym, G♭, with six flats, sounding the same and being easier to play. Should the sharp key, however, be employed, remember that when an F× occurs it must be fingered like G♮, C× being played like D♮, G× like A, and so on. The minor scales related to the foregoing sharp keys present no more difficulty than those identified with flat keys.

Take, for instance, E minor, the relative to G major. Sound E, first line treble clef, by putting down the first and second fingers. Produce the next note, F♯, by depressing the second piston only. Then comes G♮, an open note, a half-tone above. Put down the second finger for A, and the same for B, a tone above. For C♯ put down the first and second pistons, and the second only for D♯. The E, a semitone higher, is open. Returning, put down the first piston for D♮. C♮ is an open note. The second piston gives B. For A, use the first and second. G is an open note. F♯ is produced by the second piston only, and E with the first and second as before. Thus, in the melodic minor, F, C, and D are sharpened in ascending, but the D and C are made natural in descending, and only the F is sharp. So as to impress all the major and minor scales on the memory, the student is advised to write them out on music-paper in their proper order, placing the fingering above each note. Presently, no matter what key a piece is in, familiarity with its scale, both in the major and minor modes, will enable numerals over the notes to be dispensed with, and the fingering will apparently come of its own accord.

Appoggiatura. We have seen that the correct performance of saxhorn music greatly depends on familiarity with the different graduated series of sounds applicable to every key. Unless, therefore, each scale is studied independently, and the fingers as well as the lips be exercised together, so that, no matter what the

signature is, the performance will be rendered with facility, the saxhorn player cannot expect to excel on his instrument. So the scales are those ladders of sound which have to be climbed if the top of the musical building is to be reached; and the sooner their various rungs are mounted the better. But these more important exercises can be pleasantly alternated with study of the embellishments or graces which frequently occur in written music. The simplest of these ornaments is the *appoggiatura*. It is merely a little note which leans upon a big one when playing. Although smaller to the eye than the principal note, in performance it is given one half the value of the latter; but when crossed by a small line, the little note should last only a fourth of that which follows [Ex. 13].

The Turn. The *turn* consists of three grace notes played between, or after, a principal note. It is sometimes termed *gruppetto*, an Italian name for a series of notes grouped together. Such embellishments, in former times, were introduced at the discretion of a player, and it was considered clever to insert what was called in our country a "double relish." Such improvisations to-day are bad form, as they are contrary to the intentions of the composer. The turn is marked by a horizontal ~. A small sharp beneath this sign indicates that the lowest of the three extra notes must be raised a semitone, whereas, if the sharp is above the sign, the upper grace note has to be treated in that manner. When a sharp occurs both above and below the sign, both the upper and lower grace notes are raised a semitone by the player, the same rule applying as regards flats, the performer then depressing both the lowest and highest grace notes in similar fashion [Ex. 14].

The Shake. What is known as the *passing shake* is the same note twice repeated with the semitone above it, without interfering with the time in which the other notes of a bar are performed. But the *trill*, or longer shake, necessitates a rapid alternation of the note marked with that which is the next degree above it. On an instrument with pistons, playing a trill neatly and rapidly can only be effected by constant practice, and by keeping the valves in good order. Try the shake on C in third space. Couple this with the semitone below by putting down the second piston for B. Begin very slowly, playing B, C, B, C on four beats. Then sound B, C, B, and C, B, C, as two triplets, each on one beat. Next, play B, C, B, C as four quavers on one beat. Still increasing the speed, execute the two triplets as before, making six quavers to one beat. Then double the speed, and play a group of eight semiquavers to one beat, finally getting four triplets of semiquavers, or twelve notes, to one beat.

Try the next note of the scale, but an octave lower, by putting down the first and third piston for D, and alternate that with the open low C. To move two fingers instead of one evenly and rapidly is, of course, more difficult. Proceeding to the next note, E, a further difficulty confronts the student, for, whilst the first finger is kept down for both notes, the shake is executed by the third and second pistons, and the third finger is the weakest of the hand. It therefore demands an extra amount of practice. At first the shake may appear almost impossible, and it is no good tiring the lips or fingers by continuing too long with any one exercise. The best way is to attack it persistently at short intervals day by day.

Continuing the chain of shakes, go to the F This is easier. For both the E and F the first piston is down, but for the E the second is also required, so the shake is made by a rapid depression and release of the second piston. To get the shake on the G requires rapid manipulation merely of the first finger for F, G being an open note.

The shake on A is more difficult, as it requires the first and second fingers to be moved with great precision for A, and then released cleanly so that the open G is heard. The shake on B is simple, because the second piston is down all the time for B, and the first is depressed quickly for A. Finally, to complete the octave, "open" C changes rapidly with the B, so that the second finger and the lip only do the work. Thus it will be seen that the *pons asinorum* of a chain of shakes in the scale of C major is presented by the trill on E in the lower octave, where the first and second and the first and third fingers have to move neatly and rapidly. But in the octave above the E is an open note, and the D below needs only the depression of the first finger, so that what is difficult in the graver notes becomes easy with a tighter lip. It is useless, therefore, to attempt a maximum speed towards the bottom of the compass.

We only give particulars of trilling in C major, but the student is advised to study other scales in the same way, making a chain of shakes on every note by coupling with each one the semitone below it. From skilful use of this ornament, some of the most beautiful effects in music have been derived, as, for instance, Beethoven's imitation of the nightingale in the "Pastoral Symphony," or in his setting of "Herder's Song." This forms an admirable exercise, as, being based on Nature, it shows the truly artistic way of beginning a trill. It is on the top A, coupled with the G below. Now, the A requires depression of the first and second pistons and a tight

Ex. 13.

Ex. 14.

Ex. 15. BEETHOVEN.

Ex. 16.

lip. But the G in the upper octave is an open note. The bird, before it pitches on to the A, accustoms itself slowly to sounding the preceding G. First we have three slow G's in one bar. Then the crotchets are syncopated, which means that the rhythm is altered by driving the accent to that part of the bar not usually accented. So the bird begins the second bar with a short note, followed by two long ones, and then succeeded by another short note. The third bar doubles the speed, so we have six quavers instead of three crotchets; but, as the nightingale is thinking of the speed of the trill, it again begins and ends the bar with a quick note, as in the preceding instance. Then, in the fourth bar, it executes its shake on the A, singing four A's and four G's on each of the three beats, or twenty-four notes altogether in one bar. This is Nature's own method of trilling, and the student who copies such a model cannot go far wrong [Ex. 15].

Portamento. In singing this term implies "lifting" the voice from one note to another. On the saxhorn it means a tightening or slackening of the lips in a flexible way, so that the sound is increased to a higher or decreased to a lower pitch. As a valve instrument, unlike a slide-trombone, cannot make a true glissando, the idea of the portamento is merely to get the transition from one note to another as smoothly as possible. If the "carrying" is exaggerated, it becomes objectionable. But in legato music it should be the endeavour of the player to make his instrument sing. Some performers have a natural gift in this respect. Between mere blowing and artistic performance there is therefore a marked difference. Since every musical instrument has a voice, a family of saxhorns of different sizes may be regarded as a vocal choir representing bass, baritone, tenor, alto, or contralto, mezzo-soprano, and soprano parts. If a combination of singers "bark" out their notes, the effect is not considered happy. Yet many saxhorn players unconsciously cultivate a harsh, brassy manner of tone-production analogous to barking. Thus it is not alone correct finger manipulation which should be studied, but the student should always imagine that he has a critic listening to the quality of his tone, whether it be elicited from the lower or higher octave. Only by independent practice of this character can the player make his performance most useful for enriching the tone of a band artistically.

To do this requires persevering practice, and not exceptional ability. Patient self-training and taking care never to force the lips unduly by exercises for which they are unfitted will enable the student gradually to improve himself.

Self-tuition in saxhorn playing, therefore, in the absence of a master to check impetuosity, demands special restraint. One's studies, when practising alone, must be systematised. Therefore, draw up a practice table as recommended in the course for the violin [page 2314]. There it will be seen that if forty minutes can be devoted to practice daily, five of them are given to a major scale, five to a minor, a quarter of an hour being occupied by practising intervals, and the remaining quarter of an hour by the study of arpeggios. If in earnest, the saxhorn student who wishes to economise his leisure will make more progress if he familiarises himself in the same manner gradually with the different major and minor scales, makes exercises upon them, and practises the shake and portamento effects, than in playing unprofitable popular tunes.

Having mastered preliminary studies, he has only to develop carefully such rudimentary ability to become recognised by-and-by as a talented player.

Specially adapted for portamento phrasing are certain slurs, as in preceding the E on the fourth space (played with a tight lip and first and second pistons down) by open G below, or the same G preceded by the open C above, the difference from the high to the low note being due to "humouring" the tone by the lip. The rule is to make a crescendo when going from a low to a higher note, and a decrescendo when coming from a high to a low pitch. The long note, to which the tone is "carried," is slightly anticipated, whilst the shorter note is slightly curtailed [Ex. 16.]

Time Beats. Tone quality or vocal effects in saxhorn playing, however, must be subservient to the measure in which any study is written. Avoid slackening the speed over difficult short notes, and do not hurry over long, easy sounds. Emotional qualities in music are invariably governed by tempo. It is this control which constitutes "form" in music. Unfortunately, players who are the best timists have often a harsh lip, whilst those who produce the best tone-quality frequently neglect a strict observance of the beats in each bar. The easiest way to correct shortcomings in this respect is to practise with a metronome.

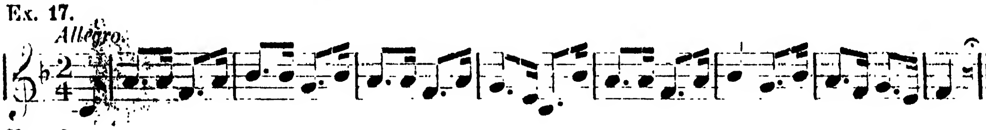
If a melody is written as a march, it should be performed as if the left foot of every soldier was brought to the ground on the first beat of each bar. Equally, if the piece is a dance, unless the rhythm is correctly kept the steps of the dancers would be thrown out. To add interest to a melody, the time within each bar, nevertheless, is often interrupted by the composer, who robs the length of one note by giving it to another. Thus, a dotted note, if there are two crotchets in a bar, borrows half the length of that time

from the crotchet which follows, so that the second note becomes a quaver. When two dots, however, follow a note, the second sound is still more abbreviated. Thus, Rossini's "Cujus Animam" starts with a dotted minim, followed by a dotted quaver, in four-four time, so that only a semiquaver is needed to complete the bar. The six succeeding bars preserve this rhythm by having notes of similar length to those in the first bar. Yet, although the measure is marked "allegretto," or tolerably quick, these dotted notes do not imply that the movement is to be played jerkily, as the music, being sacred, should be rendered seriously.

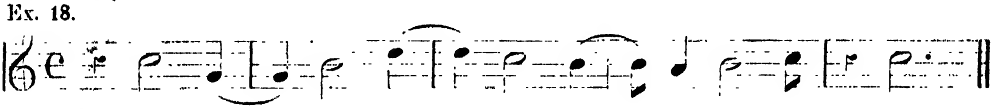
On the other hand, if we take Irish jigs or Scottish reels in quick time, the dotted notes, performed in spirited fashion, give to the piece its swing or "lilt." To accustom the student to the playing of dotted notes, a good exercise is the well-known "Keel Row" [Ex. 17].

Here, in the contraction to a semiquaver of each second quaver, the accents fall on the first and second beats in each bar, so that there is no displacement of the rhythm of the melody. But, whilst emphasis is regular so far as the tune is concerned, it may be irregular in the part written for an accompanying instrument. The student should give careful attention to any such unusual accentuation. Although the emphasis

Ex. 17.



Ex. 18.



may fall generally on the first tone in each bar, considerable effect is often gained by misplacing the accent in minor parts.

Syncopation. As an example of this, play four C's, third space, in a bar, in four-four time. But begin the second bar with a quaver rest, following this rest by blowing three crotchets and one semiquaver in strict time. To do this, count mentally "one-and," "two-and," "three-and," "four-and," giving emphasis to the "and" in each case. This is syncopation. The effect is as if the player, instead of blowing simultaneously with a conductor's beat, echoed it. Practising alone, syncopated passages may not appear interesting, and for that reason are apt to be passed over, yet they need special attention [Ex. 18].

Tuning. When any instrument of the saxhorn family is blown without touching the pistons, the student is aware that not one but different sounds result according to the degree of lip-pressure on the mouthpiece. The lowest, or fundamental, sound is obtainable by a very slack lip. As its quality is bad, this note is seldom used. The musical tones are the harmonics, or partials, elicited above the deepest sound. These, we have seen, ascend in a regular series, becoming higher in pitch according to the increase of vibratory impulse, which exhausts the prime note and lower harmonics. Thereby prominence is given to the smaller pulsating segments, or aliquot divisions of the tube, although these are also brought into requisition when the fundamental sound is produced.

It is only by increasing the velocity of the vibration that these minuter segments can be detached. If, by a slack lip, the whole tube is thus induced to sound its fundamental note, increase of breath-pressure first divides the vibrating segment in half, next into a third, a fourth, fifth, sixth, and seventh of the whole, each proportion yielding its distinct harmonic sounds. Because of their cupped mouthpieces, this takes place uniformly in all saxhorns when no pistons are depressed. When first introduced the valve-action was somewhat different to what it is now. Pressure of the first piston lowered the pitch half a tone, of the second a whole tone, and of the third a tone and a half. The arrangement now is that the first depresses the pitch a whole tone, the second a semitone, and the third a tone and a half. This system distributes, as equally as possible, the weight of the longer tubes attached to the valves. The harmonic series obtained through the medium of each piston is therefore a mere transposition in pitch of the so-called open sounds when no valves are used. Increased depth depends on the extra length of air-passage opened.

If the tubing attached to the valves is examined, it will be noticed that each lower bend is furnished with a tuning slide. A little grease will make these slides work freely. Without using the pistons, sound D above first ledger line bass clef. Compare that note with the same obtained on pressing down the third piston. Regulate the slide of the latter until the two are in tune. Sound B♭ above bass clef without touching the pistons. Then press down the second with the third, sounding the same note. Regulate the slide of the second till the unisons are true. Without touching the pistons, sound the first D again, and then the same note, putting down the first and second pistons. Adjust the slide of the first till the unisons are in tune.

THE EUPHONIUM

On account of its singing quality, power, and flexibility of tone amongst the various saxhorns, this instrument, apart from its use in filling in harmonies, is often allotted prominent solo work. The name "euphonium," coming from the same Greek root as euphony, means "smooth-sounding." It is pitched in C, B♭, or A♭, the C being least used. In brass bands the A♭ is

occasionally employed, but the B♭ is usually preferred. In common with the other saxhorns, euphonium band parts can be had in the treble clef, but the student is advised to make himself acquainted with the bass clef, solos being generally written in that manner. The method of blowing the euphonium is akin to the smaller saxhorns. Choose, however, a mouthpiece an inch in diameter at the cup surface, and even larger if the instrument has four valves.

In a big instrument a mouthpiece with a large cup gives a better tone-quality than a small one. The latter is often chosen because it is thought that high notes, usually less important than the low ones, can be more easily articulated. A point for the student to cultivate specially is to produce every note on the euphonium without beginning it with what is known as a "crash."

From very soft to very loud the quality should always be mellow and liquid. Owing to the extensive compass of this instrument, it takes the same position in a brass band as the violoncello does in a string orchestra. Recognising its resources, composers make more and more use of the euphonium.

Attitude. In this and the larger bombardon, owing to the weight of the instrument, many students get into a bad habit of bringing the mouth to the euphonium instead of the latter to the lip. Stand erect and keep the body motionless when playing. To incline the neck forward is wrong; it interferes with the proper method of breathing. Guard against contracting a bad habit of jerking the breath to complete a note, whilst at the same moment lessening the pressure on the lips of the mouthpiece. This immediately lowers the tone. Endeavour to stand in a military attitude when practising. Hold the instrument with the left hand, firmly but not stiffly. If grasped loosely, the instrument will shake on manipulation of the pistons, and the embouchûre will be upset.

THE BOMBARDON

It is a mistake to use the euphonium for bombardon work. The former, in spite of its good qualities, has neither the depth nor fulness of tone for such an important part. The bombardon student should endeavour to produce a good full tone, and sustain it without effort, rather than strive to acquire facility in rapid passages. To get the necessary dexterity of finger and suppleness of lip for playing the Flugelhorn, boys in France are put to that instrument at the age of ten, and are considered incapable of excelling on it if they take it up after eighteen. But, with the bombardon, although small models are made for use in boys' bands, the instrument can only be heard at its best when played with the reserve lung-power of a physically strong man.

The player should always seek to emulate the best effects of the stringed double-bass.

Bombardons are made in models of three different pitches, E♭, F and BB♭. The price ranges from £7 to £20.

The Fourth Valve. In the smaller saxhorns, to get correct intonation, when certain combinations are made with the three valves, the lip has sometimes to "humour" the notes. In bombardons, similar coaxing of tone is not always feasible. A fourth valve is, therefore, almost essential. When used alone it adds the length of two and a half tones to the "open" pitch. This series of harmonics then sounds: F (below bass staff), with C, F, A, C, and F above. These sounds are all too sharp in the lower register if the same notes are obtained with the first and third pistons. The tubing opened up is then too short proportionately to the whole length. With the fourth valve the series is accurate. But if this piston is valuable as regards the harmonics it gives by itself, it is of greater utility when combined with the other pistons. The student should therefore acquaint himself with the principles of the quadruple fingering. The fourth valve in combination with the second gives A (third ledger line below staff), with E, A, C♯, E and A above. The fourth and first valves together sound A♭, E♭, A♭, C♮, E♭, and A♭, lowering the first series a semitone. By the fourth and third valves being depressed, we get a whole tone lower, thus: G (below third ledger line bass clef), D, G, B, D, and G above. Putting down the fourth and second valve, there is another depression of a semitone, the sounds being G♭, D♭, G♭, B♭, D♭, and G♭. By lowering the fourth, third and first together, there is a transposition of three whole tones in the first series, and we get F (fourth ledger line below staff), with C, F, A, C, and F above. Finally, pressing down all four valves, the open series is lowered an interval of a fourth, the harmonics being low E (below fourth ledger line), with B, E, G♯, B, and E above.

Taking an E♭ instrument, the compass will be found to consist of three octaves; the upper notes of the first octave and the lower sounds of the second being easiest for the beginner to obtain. On these notes preparatory studies are usually constructed. It is only for the lowest octave that the fourth valve is needed. Nevertheless, this is the most important part of the compass, since it gives the pedal notes on which the harmonies in a brass band are constructed. These sounds, in consequence, may have to be loud and sustained. If their intonation is wrong, the effect of the other instruments will be spoilt. To master the blowing of the bottom octave, begin with the open E♭ (first ledger line below staff). Lower the second valve and sound D. With the first valve, get D♭. With the first and second together sound C. With the second and third together get B. With the first and third together get B♭. With the first, second, and third sound A.

Now, for the next five semitones the fourth piston must be employed or the intonation will be too sharp. Always using this piston, put down as well the first for A♭, the third for G, the second and third for G♭, the first and third for F, and the first, second and third for E. Finally, the octave fundamental below the E♭ from which the start was made can be obtained with a very slack lip.

Sarrusophones and Saxhorns concluded

PAINTS AND POLISHES

Grinding Mineral Colours. Artificial Pigments. Tests for Colours. Linseed Oil and other Mediums. Resins. Varnishes. Metal and Boot Polishes

Continued from page 4072

By CLAYTON BEADLE and HENRY P. STEVENS

The first object for which a coating is applied to the surface of a substance, whether it be painted, varnished, or polished, is the preservation of the surface. It does not matter whether you are painting an iron girder, tarring a fence, varnishing a table, or polishing a pair of boots, the object is always the same—namely, to protect the surface of the material, whether iron, wood, or leather. All substances when exposed to the action of the atmosphere are gradually destroyed and disintegrated, whether the material rusts, moulds, rots, or undergoes any other change. All these transformations are of a chemical nature and are usually caused by the oxidising effect of the earth's atmosphere. These destroying influences are much accelerated by the presence of moisture, and in lands with a very dry climate, such as Egypt, the atmosphere has little or no destructive effect. However, in our own and most other countries, it is generally necessary to coat or paint materials with a more resistant substance to preserve and lengthen their life. The sort of coating to be applied will depend on the circumstances. Thus, a light polish will do for a table away from the air and damp, but a very strong and resistant paint is required for an iron girder exposed to sun, storm, wind and rain.

Æsthetic Considerations. We have, up to now considered paints and polishes purely in respect of their utility, but in most cases there is also an æsthetic side to the question, and we have to combine beauty with utility. The former, however, cannot replace or make amends for any deficiencies in the latter. Even when painting easel pictures, although the artist's aims are purely æsthetic, he must, nevertheless, choose such pigments as are durable and permanent, and must discard those, no matter how brilliant of hue, which have not the necessary permanence. We have only to study the paintings of some of the great masters, even the more modern, such as Turner's, to realise how insufficient attention to the permanence of the colours has impaired many otherwise excellent achievements.

Without, however, attempting to follow the purely æsthetic side, it is necessary that a paint should be effective in appearance and pleasing to the eye. This has brought about a demand for paints of brilliant hue, and for varnishes and polishes of the brightest gloss, which has sometimes resulted in the substitution of the cheap and gaudy for the sombre but more permanent colours. Bright colours, such as aniline lakes, have replaced the more permanent mineral colours. Those engaged in constructive work should make sure that they are getting the genuine mineral colour when they order it, and not a mixture of inferior mineral with aniline lake or other fugitive colours added to produce the same effect, and this can be accomplished only by a chemical analysis. On the other hand, we cannot expect to get a genuine mineral colour, say, for instance, vermilion (sulphide of mercury), when we are willing to pay only the price of an inferior article, such as vermilionette (barytes or red lead, coloured with aniline lake). Such pigments bear much the same relation to one another as flannel (wool) does to flannelette (cotton).

Pigment and Medium. A paint consists of a mixture of a solid pigment or coloured matter ground in with a vehicle or medium such as oil. The pigment is in the form of a fine powder, and is applied to the surface to be coated in intimate admixture with oil. As the latter gradually dries, it hardens to a tough elastic mass, adhering firmly to the surface and binding together the particles of pigment. Only some of the many vegetable oils with which we are acquainted can be used for this purpose, as only a few of them possess the property of drying, hence, called *drying oils*. The best example of such oils, and the one most commonly used, is linseed oil.

Natural and Artificial Pigments. We may separate the pigments into two classes: (*a*) those which we find naturally occurring, such as ochres, barytes, and china clay; (*b*) the larger class of artificially prepared pigments. A few colours, such as iron oxide reds, both occur naturally and are prepared artificially.

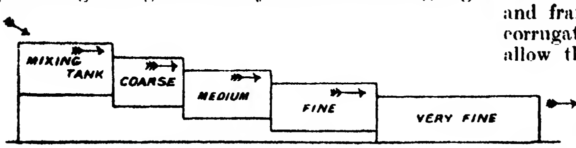
But even though the pigment may be found ready made in Nature, it requires considerable treatment to get it into a suitable form for grinding with oil. The mineral is found in lumps or powder of various-sized particles mixed up with impurities of one sort and another. The cheapest and most commonly adopted process for purification is known as "levigation."

How the Process is Operated. If we stir up in water a powder of different-sized particles, and then allow them to settle, the larger and heavier sink first, the smaller and lighter remain longer suspended in the liquid. If we leave the mixture sufficient time for the whole of the powder to deposit, we shall find the larger particles at the bottom, and the smaller at the top, so that a sort of separation has been effected; but if, instead of allowing the water to remain still, it is made to move slowly forwards, say, through a tank, entering at one end and leaving at the other, we shall find the coarsest particles deposited at the nearest end and the finest particles at the further end, so that on draining off the water the sludge of coarse particles can be dug out and kept separately from the finer ones. Better still, we may use a series of tanks and allow the water and mineral matter to pass through one to the other [1]. In the first tank we shall have the coarsest particles, in the second tank the medium-sized particles, the third tank will contain the fine particles, and the last tank the very fine ones. As the suspended matter takes an increasingly long time to settle, it is better to make the tanks increasingly larger, so as to give time for the deposit to form. Each tank should be built a little lower than the previous one, so that the water may flow by gravitation from one to the next. After allowing full time to settle, the water is drawn off from each tank and the sludge dug out from the bottom. It will be seen that we are thus possessed of an excellent and cheap method of treating earth

colours which is so economical and efficient that it is applied not only to earth colours but also to artificial colours, such as ultramarine, where a uniformly finely divided pigment is not obtained straight away.

A Practical Test. A rough examination of the material taken from the different tanks will demonstrate the separation which has been effected. Supposing we have been working with china clay, the first tank will contain a product consisting of tiny particles of rock, known as *micaceous clay*. A pinch of this product dropped into a tumblerful of water will present a very different appearance to a pinch of the fine material from one of the later tanks.

Grinding under Water. In most cases previous grinding is necessary, whether we are going



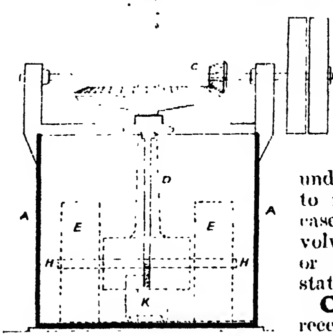
1. LEVIGATING TANKS

to levigate natural or artificial colour. For this purpose a wet grinding mill [2] is used, which consists of a strong circular iron tank, AA, containing water into which the material to be ground is put. A strong vertical shaft, D, driven by the pulleys, B, and the gearing, C, revolves in this tank, and to it is attached the horizontal shaft, HH, on which the rollers, EE, are free to revolve. Those portions of the mechanism immersed in water in the tank are represented by dotted lines. When the machine is set going, the rollers or runners, EE, move in a circular path, resting on the bed or bottom of the tank, AA. The lumps of colour are crushed and ground between the rollers of the bed-plate, and the coarse particles rapidly settle again to the bottom, where they undergo further grinding and crushing while the finer particles remain suspended in the water and are drawn off with it in a regular stream through cocks in the side of the tank. The construction of this grinding mill as built by Follows & Bate may perhaps be better understood by reference to 7, where we have a similar plant, but suitable for grinding in the dry instead of the wet. There is a gate, K [2], at the bottom of the tank for taking out coarse unground lumps. Attached to the shaft, D, are scrapers, which revolve, touching or nearly touching the bottom of the tank. These are not shown in the illustration, but serve to gather up the ground lumps and distribute them over the surface to ensure even and uniform grinding.

Pressing and Drying. Our colour is now in the form of sludge, and the water has to be got rid of. In some cases it may be dried directly in some suitable form of oven. Whatever type of oven is used, it is essential that there should be a thorough circulation of air through it, fresh air being admitted while the air laden with moisture is drawn off. Very often it is more economical to remove most of the water by filtration, and even to apply considerable pressure to squeeze the mass as dry as possible, as, quite apart from the expense of evaporating large quantities of water, such water may also contain soluble impurities which can be removed only by filtration. The moist colour can be thrown on a simple filter cloth stretched over a frame, but it is usually more economical to use a filter press. Fig. 3 represents the latest type of machine, which is made up of a number of square frames [4]. These frames have a circular hole, A, in the middle, and the edge projects all the way round, so that when put side by side, as in 3, they form a number of enclosed cells. The filter cloths are cut the same size as the frames with the hole in the middle made slightly smaller. They are sewn together in pairs, by joining the edges, where the holes are cut, and each frame is fitted with a pair of cloths, by pushing one of the cloths through the hole A, in the centre of the frame, so that each side of the frame is covered with a cloth. The frames are then placed side by side, and held firmly together, as shown in 3. The [illegible] or liquid mass of material to be filtered, is forced [illegible] by the pumps shown at the near end of the machine and the liquid finds its way through the filter cloth into the space between the filter cloth and frame. The surface of the frame is usually corrugated, as shown by the cross lines [4], to allow the liquid to run off and find its way out through a hole at B, near the bottom of each frame. The frames are also provided with arms, CC, to support them, and are screwed up together as tightly as possible. When sufficient stuff has been forced into the machine, the material can be washed by subsequently forcing water through. Finally, on taking the machine to pieces, a solid cake of colour can be removed from between each pair of frames.

Grinding Machines. The solid material is now ground. This can be effected in the edge-runner mill [7], shown in section in 6, the [illegible] of which is exactly similar to the wet grinding mill [2] already described. It will be noticed [illegible] is under-driven, the gearing, C, being under [illegible] A. The axle, HH, is not rigidly fixed on [illegible], D, but there is a certain amount of "give" [illegible] by the springs, M, so that, should the [illegible] over a hard lump of material [illegible] crush, it just lifts the axle, HH, a little, [illegible] possibly breaking some part of the machine.

Flat Stone Mills. [illegible] of grinding mill the powder is crushed [illegible] the flat sides of two circular stones, instead of between the edge of the stone and a bed-plate. Fig. 5 will give an idea of what is intended. The material is fed in through a hole, A, in the upper stone, and finds its way out at the edges, BB. Sometimes it is the upper stone, sometimes the under that is made to revolve. In either case one of them revolves while the other or bedstone remains stationary.



2. WET GRINDING MILL

Cone Mill. As a recent type of another form of mill we may take the cone mill or disintegrator, as shown in 8, a section of which is shown in 10. The material is fed in to the hopper, A. The pulleys, B, by means of the gearing, C, drive the conical-shaped block, E, with the corrugated surface. This block, shown black in 10, revolves close to the outer grinding surface, HH, and the material passing down between the two is rapidly reduced to a fine powder, and collects in a groove round the base of the

block, E, and passes out through D. This form of mill is very well adapted for rapidly grinding soft materials, and it is also used for wet colours.

Mixing Machines. At a certain stage, the ground colour is incorporated with the medium—usually oil—to make the paint, after which the mixed colour and oil undergo a further grinding in a special form of mill termed a *roller mill*, which we shall come to shortly. Figs. **9** and **11** show a vertical mixer, which consists of a pan, AA, to take the oil and colour. The pulley, B, by means of the gearing, C, causes the vertical shaft, D, to revolve. This shaft carries horizontal beaters or agitators, HH, which revolve, ensuring thorough incorporation of the dry colour with the oil. When sufficiently mixed, the mass of paint is run out by means of the gate, K, worked by the handle, L, at the bottom of the pan.

Roller Mill. This form of mill [**14**] is used for the finishing process; the paint, going through the mixer of pug mill, is ground to an impalpably fine mass with the oil. Fig. **13** shows longitudinal section, and **12** a vertical section and the more important parts of a roller mill. It will be seen that it consists of three rollers, A, B, and C, touching, or almost touching, one another. They are held together in the frame, KK, and are adjusted by the handles projecting from the ends of these frames. The driving gear is left out in the illustration for simplicity, but the gearing is shown by which the motion of the roller B is transmitted to the rollers A and C. As the wheel D is larger than E, and E than G, it will be seen that the rollers will revolve at different rates. The speeds, shown in **13**, are not always adhered to but adjusted to suit the work. The mixed paint, as it comes from the pug mill, passes on to the roller A, and is kept from off the edges by the blocks of wood, LL. Owing to the fact that the rollers revolve at different rates the material is subjected to a smearing and grinding action, which reduces it to a fine state of subdivision. From the roller A it passes to the roller B, and from B to C. A scraper, M, is adjusted against the roller C, which collects the ground paint, which is now ready for use.

Manufacture of Pigments. We shall consider in turn first the pigments, or colouring matters, then the vehicles or mediums.

Pigments and colouring matters are either of mineral or organic origin. Speaking generally, the mineral colours are far more permanent than the vegetable and animal colouring matters or the aniline dyes which are also used. We shall consider first the more important mineral colours, describing shortly their methods of manufacture and properties.

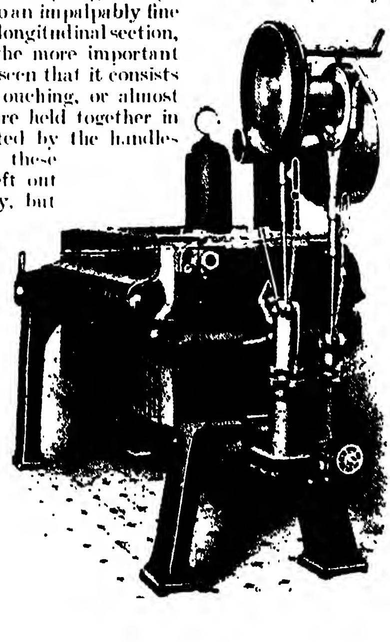
White Lead. This substance is a basic carbonate of lead, having the chemical composition approximately represented by:

$$2PbCO_3.Pb(OH)_2$$

(Lead carbonate) (Lead hydroxide).

The use of this colour can be traced a long way back in history, and the old method of preparation known as the Dutch process, although less convenient than the modern methods, produces the best quality of material. The Dutch process is shortly as follows.

A small quantity of vinegar or acetic acid is placed at the bottom of an earthenware pot, provided with a shoulder about halfway up the side. On this shoulder rests pieces of lead, roughly cast in the form of a grating. A large number of these pots are placed together on a layer of spent tan, the whole is covered with another layer of spent tan, and a further layer of pots upon this until the whole forms a large stack. The decomposition of the spent tan raises the temperature of the whole mass, causing the acetic acid to volatilise, and act on the lead plates forming basic lead acetate. Carbonic acid, which is evolved at the same time from spent tan, partly decomposes the basic acetate, forming basic carbonate, and the acetic acid liberated acts on a further quantity of lead. The white lead so produced is collected by crushing and separating the powdery pigment from unchanged metal.



3. FILTER PRESS (S. H. Johnson & Co., Ltd.)

In a more modern method, litharge is ground up with common salt and water, with the formation of a solution of the oxychloride, from which white lead is precipitated by a current of carbon dioxide gas. White lead forms an excellent paint on account of its body or covering power; that is to say, when ground up with oil and spread over a surface a very small quantity of the material produces an opaque layer. It also reacts chemically in some way with the linseed oil with which it is ground, producing a hard drying layer. Its chief disadvantage is the discolorisation it undergoes when exposed to a sulphurous atmosphere, black sulphide of lead being formed.

Zinc white is an excellent white paint, consisting of oxide of zinc, but it is too expensive for most purposes. There are, however, a number of white paints, known as zinc whites, which contain a small proportion of a zinc compound in admixture or combination with cheaper materials.

Lithopone belongs to this class of zinc whites, and contains zinc as a sulphide. The zinc is often precipitated together with barium sulphate, which forms the larger part of the pigment, or, as it is commonly put, the zinc is "struck" on barytes.

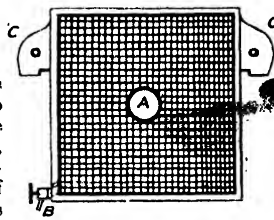
Barytes, or *permanent white*, consists of the mineral barytes finely ground. It is extremely permanent, but has little covering power. It is used in enormous quantities for cheapening pigments. We shall come across it again later on. An artificial form of barytes known as *blanc fixe*, is made by precipitation.

Paris White, or Whiting. This substance is identical in composition with chalk—that is to say, it consists of calcium carbonate. It is essentially a cheapening agent or an adulterant of

other pigments. It is frequently used in admixture with two or three parts of barytes. These cheaper whites are not always as economical as they appear, as a larger proportion of oil is required for grinding them. Thus, white lead and the very best permanent white takes about 7 per cent. of oil for grinding, whereas whiting will take as much as 23 per cent. White lead or the cheaper zinc whites, such as lithopone, form the basis of most paints, especially light coloured ones.

We shall consider the coloured pigments in order.

Ochres and Siennas. Ochres are so-called *earth colours*—that is to say, they are natural earths that have been subjected to a refining process, consisting of grinding, the plant required varying with the hardness of the material, then levigating—that is to say, grinding up with water [2] and allowing the small particles to settle, draining off the supernatant liquor containing the fine particles, and allowing these to settle in separate tanks [1]. Finally, the water is drained off, leaving the finely divided pigment as a deposit.

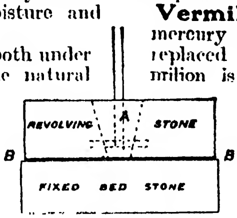


4. FILTER PRESS FRAME

Ochres, speaking broadly, are compounds of oxide of iron and clay—that is to say, when analysed the main constituents, in addition to moisture and oxide of iron, are alumina and silica.

These colours are very permanent, both under light and atmospheric influences. The natural ochres are found in Oxfordshire, Derbyshire, and on the Continent.

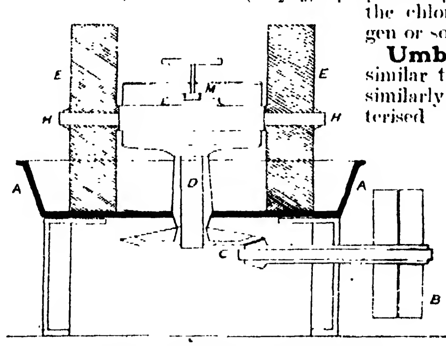
Chromes. These are brighter than the ochres, not quite so permanent, but sufficiently so for most purposes. They consist generally of chromates of lead prepared by precipitating a solution of lead salt with potassium bichromate. Each of the components is dissolved in separate receptacles · wooden tubs with stirrers, and heated by live steam, are suitable; they are then mixed in a third vessel where the colouring matter is precipitated.



5. DIAGRAM OF FLAT STONE MILL

Different proportions of acetate or nitrate of lead to bichromate yields chromes of different shades. The paler shades frequently have sodium sulphate dissolved with the bichromate, so that the colour consists of a mixture of lead chromates and sulphates. Ground barytes is frequently incorporated. To obtain orange shades, solutions of caustic alkalies are used which produce a basic lead chromate of composition $PbO.PbCrO_4$.

Chrome yellows are also made from zinc and barium salts, which yield zinc and barium chromates. There are a number of other yellow colouring matters, such as Mars yellow, which is a sort of artificial ochre made by precipitating together oxide of iron and alumina.



6. EDGE-RUNNER GRINDING MILL

Turner's yellow is obtained by calcining a well mixed paste of litharge and common salt.

Naples yellow contains antimony compounds, generally mixtures of oxides of antimony and lead.

King's yellow is an artificial orpiment or sulphide of antimony.

Cadmium yellow is sulphide of cadmium precipitated by sulphuretted hydrogen from a slightly acid solution of cadmium salt.

Cadmium orange is prepared in a similar manner, using strongly acid solutions of cadmium.

Aureolin is a double nitrite of potassium and cobalt. These last-mentioned yellows are very permanent, and much used by artists. They are, however, too expensive for house painting.

Red Lead. This substance is an oxide of lead having approximately a composition represented by the formula Pb_3O_4, and is obtained by roasting litharge until it acquires the desired colour. It is an excellent pigment and mixes well with oil. It has a peculiar action on linseed oil, which causes it to dry rapidly, due to the fact that it saponifies the oil and forms a mass of red lead cemented with lead soap.

Venetian red is an oxide of iron. It is obtained from natural sources, by grinding the hard rock, or is made artificially by roasting copperas (sulphate of iron). It can also be precipitated by a wet process. It is a very permanent colour.

Vermilion. True vermilion is a sulphide of mercury (HgS), but for house painting is largely replaced by inferior substitutes. The best vermilion is of Chinese origin, and in China its use dates back for centuries. It is prepared by heating together a [illegible] of mercury and sulphur, and the resulting mass is then more [illegible] heated, so that the vermilion [illegible]—that is to say, it is converted into vapour, and deposited again in the cooler parts of the apparatus. [illegible] sorts of vermilion, as prepared in China, are purified by levigation in solutions of gum in which the colour settles only slowly. Inferior vermilion is prepared by the wet method of precipitation, and washing the resulting product. Vermilion has a great covering power, and is a very permanent colour.

Antimony vermilion is a sulphide of arsenic (As_2S_3), prepared by precipitating a solution of the chloride with sulphuretted hydrogen or sodium thiosulphate.

Umbers. These are earth colours, similar to the ochres and siennas, and similarly prepared. They are characterised by containing the element manganese. They are permanent and good pigments.

Vandyke Brown. Pigments of quite different origins are met with under this name. For house painting, vandyke brown usually consists of a mixture of lamp or other blacks, and ochres or reds. For artist's use, it is made by calcining vegetable matter in closed vessels. The first variety is permanent, and the latter only partly so.

Coppagh brown, and other browns of less importance, are used by artists.

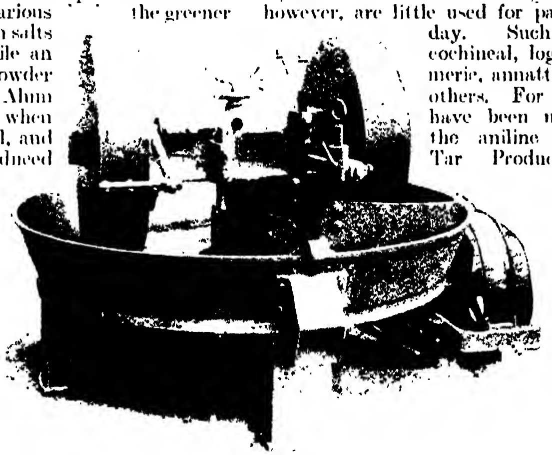
Ultramarine. This blue was originally obtained by grinding the lapis lazuli [see Mineralogy]. It is now made in huge quantities artificially. The

ingredients consist of china clay, or kaolin, which must be free from iron and contain only a trace of lime, sodium sulphate, sodium carbonate, sulphur, coal or charcoal, resin, finely powdered quartz, and kieselguhr, or infusorial earth [see GEOLOGY]. The proportions differ according to the product required. For some ultramarine no sodium sulphate is used; such is termed *soda ultramarine* and is of a violet blue tint. The ultramarine containing sodium sulphate has a more greenish hue. The thoroughly mixed ingredients are calcined in covered pots in a furnace and yield a greenish product. This is reduced to a fine state of division and mixed with sulphur, and again heated. The resulting product is ground, washed, and levigated to remove a quantity of soluble sodium salts. Ultramarine is a permanent colour of a beautiful blue shade. The more silica used the deeper the shade. It is permanent under ordinary conditions, but the colour is discharged by weak acids. It cannot be used in mixtures with lead compounds, as black lead sulphide would be formed owing to the sulphides contained in the ultramarine.

Prussian Blue. Varieties of this blue are known as Chinese, soluble, Antwerp and Brunswick blues. It is produced in various the greener shades by precipitating iron salts with yellow prussiate, while an addition of bleaching powder produces an intenser blue. Alum is added to the solution when lighter shade is required, and violet tinted blues are produced with red prussiate. It is a permanent colour unaffected by dilute acids decomposed by alkalies. It has the disadvantage that it is extremely hard to grind.

Cobalt Blues. These blues are among the most permanent and are of a beautiful shade. They are, however, too expensive for use on a large scale, but form with ultramarine the most important blues in the artist's palette. There are two classes firstly, *smalts*, which is a blue glass, and is prepared from a mixture of silica and potash (not soda) with cobalt ore. The mixture is fused in a furnace, and the blue glass finely ground. The silica must be free from iron and alumina. The colour is very permanent, but the pigment does not mix well with oil. *Cobalt blue*, used largely by artists, is prepared by precipitating oxide of alumina and cobalt together. The precipitate is dried and heated in a crucible. The colours are very permanent. There are a number of other blues, such as the copper blues (basic copper carbonates), coeruleum, etc., which are of less importance.

Greens. For many purposes these are made up of a mixture of blues and yellows. Thus, Brunswick green is commonly a mixture of Prussian blue, chrome yellow, and barytes. Chrome greens, such as Guignet's green, are not to be confused with greens, such as Brunswick greens, containing chrome yellows. Guignet's green is prepared by roasting a mixture of potassium bichromate and boracic acid. The resulting chromium oxide is ground, washed, and levigated.



7. EDGE-RUNNER GRINDING MILL (Follows & Bate, Ltd., Manchester)

Emerald green is a peculiar bright, vivid green, prepared by adding sodium arsenite to copper sulphate. The resulting copper arsenite is allowed to stand with an excess of acetic acid. The colour so produced is chemically an aceto-arsenite of copper. It is permanent but poisonous in character, and is often replaced by aniline lakes [see Lakes].

Terra verte is a natural green earth, like the ochres. There are other greens of less importance, such as verdigris or basic acetate of copper.

Lampblack. This is essentially soot prepared by calcining waste oils, greases, coal tar, etc., in special ovens [see also Coal Tar Products]. The lampblack from coal tar is not quite so high in quality as that prepared from oils and greases.

Bone-black is obtained by charring bones. It has not the depth of colour or brilliancy of lampblack. Ivory black is prepared by charring waste ivory cuttings. Animal black, or animal charcoal, is obtained from animal matter of all kinds. All these black pigments are permanent.

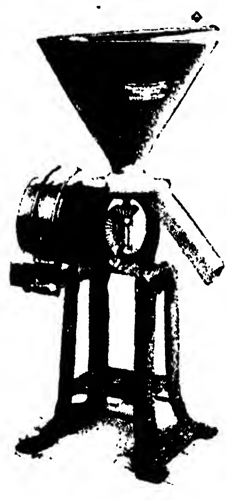
Organic Pigments. The colours which we have already spoken about are minerals or of mineral origin. There are also a number of colouring matters of animal or vegetable origin, which, however, are little used for paints at the present day. Such substances are cochineal, logwood, saffron, turmeric, annatto, and a number of others. For making paints they have been mostly replaced by the aniline colours [see Coal Tar Products]. These are generally used in the form of lakes. We should not omit to mention gamboge, an orange-coloured resin yielding a fine yellow in water. Unfortunately it is not permanent.

Lakes. Lakes are insoluble pigments prepared by precipitating an organic colouring matter with metallic salts. Thus, if to a solution of alum be added some cochineal, and then carbonate of soda, the precipitated alumina will carry down with it the colouring matter of the cochineal, and on washing and drying we shall have an insoluble red pigment. Many lakes made in this manner, especially the madder lakes, are used by artists. Working on a large scale the colouring matter is always an aniline dye, and the products are not pure lakes in that there is always incorporated with them a certain proportion of inactive substance termed a *base*. This base usually consists of some white pigment, such as barytes, gypsum, china clay, whiting, or a zinc white. The dye is precipitated upon this base by what is termed a *precipitating agent*. This will vary according to the type of aniline dye which is used. Thus, for basic dyes [see Coal Tar Products], tannic or picric acids are used, and for acid dyes, lead acetate, aluminium sulphate, or barium chloride. Adjective dyes are more difficult to precipitate. Aluminium acetate is often employed. The process of manufacturing the lake is simple. The dye is dissolved in water in a tank to a 10 per cent. solution. The precipitating agent is dissolved in a separate vat,

and in a third vessel, the base, which of course is insoluble, is thoroughly mixed and incorporated with hot water. The solution of dye is then run in and mixed with the base, the whole heated to a suitable temperature, and then the precipitating agent added. After mixing thoroughly, the lake is allowed to settle. The supernatant liquor should be colourless, showing that all the colour has been precipitated. After washing with water, the lake may be filtered off and dried at a low temperature. These aniline lakes cannot compare, so far as permanency goes, with the mineral colours, but they are often much cheaper and serve as substitutes for many of them. Thus, vermilionette is a substitute for vermilion, and consists of an eosine lake, precipitated on a base consisting of barytes or red lead. It is, of course, a fugitive colour, although some lakes are more permanent than others.

Chemical Tests. We must here refer to the course of chemical analysis, as paints are frequently mixtures of different pigments, and the analysis is often a complicated matter. In some cases, however, it is simpler. Thus, there is no difficulty in testing a sample of white lead for an adulterant such as chalk, or in determining the proportion of barytes and zinc in a sample of lithopone, or determining whether a sample of green paint owes its colour to a mineral green or to an aniline dye.

Physical Tests. The covering power of a paint is one of its most important properties. This will depend partly on the nature of the pigment, and partly upon the fineness to which it is ground. This latter consideration applies especially to materials such as barytes. It is not always economical to work with a cheap and coarsely ground sample; not only is its covering power much less, but it requires a larger proportion of oil for grinding. The fineness to which a paint is ground is usually tested in a very rough and ready manner—by the feel of the dry pigment between the fingers, or by working it on a piece of glass with a palette knife. Although this test is not of much use in determining the exact fineness of the grinding, it is useful in detecting particles of grit. To test the covering power, equally small quantities of the sample and of the standard are ground up with a quantity of oil, and spread as evenly as possible over glass plates of the same area. The relative power of the two samples to produce a good colour is noted.



8. CONE MILL OR DISINTEGRATOR (Follows & Bate, Ltd.)

In addition to the covering power, or body, it is sometimes necessary to test the colouring power of the pigment. For this purpose it is useful to mix a known weight of the pigment with three or four times its weight of some indifferent white pigment such as china clay. The higher the colouring power of the pigment in question the deeper the colour it will impart to the china clay. Some pigments, especially the aniline lakes, have very high colouring power, and only a very small quantity is required to give the necessary intensity of colouring to the base. Finally, there is the permanence or durability of the colour to be considered.

As a general rule the mineral colouring matters are the most permanent, and stand exposure to light and air better than any others; while the aniline dyes, although they give colours of great intensity, fade rapidly when exposed to the light.

To test a sample for colour, it is exposed, together with a standard colour, in a thin layer, to sunlight, and the fugitive or permanent character of the colour can be judged by comparison with the standard.

Many of the mineral colours are largely adulterated by use of small quantities of aniline colours, and this test is of special importance for testing the genuineness of these articles.

For many practical purposes it is essential to have some means of estimating the exact shade or tint of a colour. The "tintometer," invented by Lovibond, is the instrument generally used.

Linseed and Drying Oils. Linseed oil is obtained by crushing and extraction from the seed. It is used more than any other for the purpose of mixing paints and is found specially suitable on account of its drying power. It appears that by absorption of oxygen from the air it is converted into solid substances, forming a tough skin, coating the surface on which it is deposited. For paint-mixing, linseed oil is required of different grades and qualities. Raw linseed oil usually undergoes a refining process to remove a small proportion of albuminous and mucilaginous matter.

For many purposes a quicker drying oil is required than ordinary linseed oil, and to produce this effect it is heated and air passed through it whereby a certain amount of oxygen is absorbed, and a product produced somewhat thicker than linseed oil, termed *boiled oil*. The rate of drying can be accelerated by the incorporation of small quantities of certain chemicals with the oil, usually added in the process of boiling. Such substances are litharge, manganese borate, and other compounds of lead and manganese. A very small quantity of any of these substances stirred in and heated with the oil considerably accelerates the drying.

Linseed oil is occasionally adulterated with other oils, such as resin oil and mineral oils. A number of tests can be applied for detecting the presence of adulterants, such as specific gravity, flash point (to detect resin oils or mineral oils), and, in addition, certain chemical tests, such as the sulphuric acid test, iodine absorption, etc.

Another good drying oil used to a certain extent, especially by artists' colourmen, is *poppy oil*. It is very pale in colour, but much more expensive than linseed oil.

Resin Oil. This is obtained by decomposing resin, the residue left after distilling off turpentine from the crude gum. The resin is placed in large cast-iron stills, which are connected with condensers, and distillation is carried on in the usual manner.

The distillate is collected in separate fractions, of which crude resin oil is one, making up some 85 per cent. of the whole distillate. It is refined with sulphuric acid and caustic soda and then re-distilled.

It is largely used in compounding a cheaper class of paints. It is not a drying oil, and has certain disadvantages. After drying down by evaporation it has a tendency later on to become soft and sticky.

This property especially reduces its value for paint-making. As its specific gravity is ·980 to ·995 or higher, and that of linseed oil is about ·932, the adulteration of linseed oil by resin oil is apparent in the increase of specific gravity.

Resin oil is unsaponifiable—that is to say, it is not converted into soap by boiling with alkalies. In this respect it behaves altogether differently from linseed oil, which is saponified like all other fatty oils. If a mixture of the two be boiled with soda, the linseed oil only will be saponified, leaving the resin oil behind, and the amount of the latter may thus be practically determined.

Turpentine. Turpentine, or oils of turpentine, frequently known as *turps*, is the product of distillation of the crude gum exuding from pine-trees. The distillation is generally carried on close to the spot where the material is collected. It is American, French, or Russian in origin. The turpentines differ in quality, not only on account of the differences in methods of tapping the trees and distilling, but also in the variety of tree from which the gum is derived.

Turpentine is a chemical substance of the formula $C_{10}H_{16}$ [see Organic Chemistry]. It is a mixture of a number of allied substances having the same percentage composition. It is very light, its specific gravity being only ·867, and this is a good test of its purity. It is very frequently adulterated, especially with petroleum, shale naphtha, resin spirit, and coal-tar naphtha

The specific gravity of all these substances, with the exception of the last, is higher than that of turpentine. The best method of testing the purity of a sample of turpentine, apart from the specific gravity, is to distil the sample fractionally, as the adulterants have a considerable effect on the boiling-point. Petroleum spirit and shale naphtha are the low boiling hydrocarbons derived from petroleums [see Petroleum]. Resin spirit is obtained with resin oil, but comes over in an earlier fraction. Coal-tar naphtha consists of the lower-boiling portions of coal-tar distillates [see Coal-tar Products]. Such substances as these, mostly adulterants, are to be found on the market under fancy names. But, whatever their composition, they are not equal to turpentine for paint-making, and are more or less good or bad according to the constituents of which they are composed.

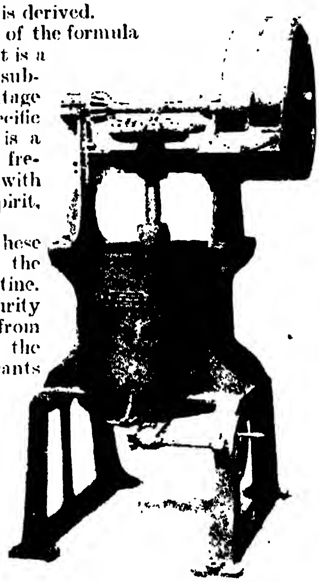
Methylated Spirit. In this place we may also mention methylated spirit as a useful solvent in varnish-making. Ordinary methylated spirit is a mixture of rectified spirit of wine and wood spirit, the former being ethyl and the latter methyl alcohol. In addition to this, small quantities of petroleum are added to make it nauseous and undrinkable. It is an excellent solvent for most of the resins, and is used in making the spirit varnishes.

Varnishes. By far the greater number of varnishes are what are termed either *oil varnishes* or *spirit varnishes*. They consist of resins in some form or another (usually termed *gums*) incorporated in the case of the former with linseed oil and turpentine, and in the case of the latter with methylated spirit or a substitute. We may enumerate, in addition, water varnishes, pyroxylin, and certain natural varnishes. As almost all varnishes contain resins or gums as the essential ingredients, we shall consider these first.

Most people are familiar with common resin, or *colophony*, such as is used for rubbing on violin bows. This substance is the residue from the distillation of products which exude from pine-trees, when the bark is cut or injured, and is left in the retort after the turpentine has distilled over. It has been mentioned above as yielding resin spirit and resin oil when distilled. It is, perhaps, the commonest of the resins, and is largely used for making the cheaper varnishes.

It varies in appearance and quality, sometimes being pale in colour and transparent ("window-glass resin"), and at other times much darker in colour, sometimes almost black. These latter varieties yield correspondingly dark-coloured varnishes.

For the better classes of varnishes (generally termed *carriage* and *cabinette* varnishes), gums of a better class are employed. These are usually fossil resins, and are much harder and more difficult to fuse, but they yield the very finest varnishes. Of these the following are the more important.



9. VERTICAL MIXER
(Follows & Bate, Ltd.)

Fossil Resins. The fossil resin amber is found in certain strata known as the Greensand Beds, which make their appearance on the surface of the earth as a narrow band, running from England across Holland and the Baltic [see Geology]. The amber is either washed up from the sea, owing to the disintegration of the rock under the water, or else it is mined, as in some parts of Germany. Of course, amber is mostly too expensive for use in varnish-making, but the amber waste and inferior pieces form suitable material.

The fossil resins mostly used are animi, copal, and kauri. Animi is the best varnish resin. It is found a few feet beneath the soil in the district of Zanzibar. It is usually identified by a peculiar, very characteristic, wrinkled appearance of the surface, commonly called *goose skin*.

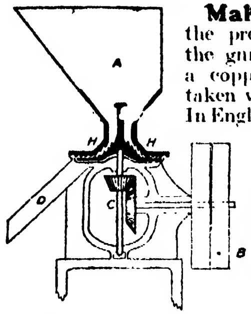
Copal includes a number of fossil resins from Africa.

Kauri resembles copal, and comes from New Zealand.

Resins. Dammar is a resin which exudes from certain trees growing in Java, Borneo, and in the neighbourhood of the Straits Settlements. It is rather inclined to be soft and friable. In addition, we may mention sandarac, mastic, Manila copal, and, finally, the different varieties of lacs.

The lacs are the resinous exudation of a number of different trees growing in India, China, and the Malay Archipelago. The exudation is caused by puncture of the bark by the lac insect (*coccus lacca*). The commonest variety is shellac, which consists of the resin purified by heating and filtering through cotton cloths. Good qualities have bright orange colour.

The other constituent of oil varnishes is linseed oil, which should be of the very best quality.



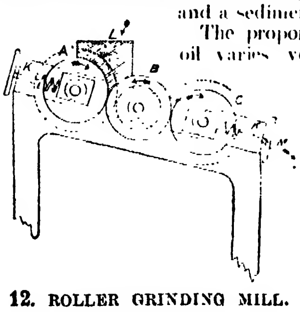
10. CONE MILL, OR DISINTEGRATOR

Making Varnish. For the preparation of varnishes, the gum or resin is melted in a copper pot. The quantity taken varies in different works. In England, a common quantity is 50 lb., but in America, according to Sabin ("Technology of Paint and Varnishes"), 100 lb. or even 125 lb. is the usual amount. This melting process, termed "gum running," requires very careful manipulation. A large quantity of inflammable gases are given off, amounting to at least 25 per cent. of the weight of the gum, so that the pots have to be provided with suitable hoods and draught to carry off the gases. In order to avoid as far as possible the danger of the gum catching fire, the pot is set on a fire fed from the other side of a partition. The temperature of the molten mass will seldom be below 650° F.

While the gum is being run, the linseed oil is heated in a boiling pot to a temperature generally not exceeding 500° F. The heating may be prolonged for an hour or two. The oil is then run into the "gum pot," and thoroughly mixed, and the heating must be continued for some time, in order to bring about a thorough action between the gum and oil. If a drop of the mixture be removed immediately after mixing, and cooled on an earthenware plate, it will form a cloudy mass, owing to the separation of the gum from the oil. When the reaction between the gum and the oil is complete, a drop taken up will remain transparent on cooling. This test is useful as marking the completion of the process. According to Sabin, it is usual to take the temperature of the mixture as a guide to the completion of the reaction, it having been previously determined by preliminary experiments how long the two must be heated together in order to procure a complete interaction. As a general rule, the larger the proportion of oil to gum the longer the heating required.

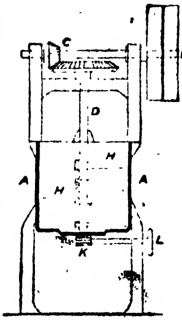
After the mixture has sufficiently cooled, it is gradually thinned with turpentine. As the thinning cannot be done cold, and the turpentine is very volatile, the thinning shed should be situated away from any fire or flame of any kind, for fear of the heavy vapours of turpentine given off catching fire. Instead of turpentine, benzene is sometimes used, but it produces an inferior product. The varnish is not fit to use at once, but has to be stored for twelve months or so in iron tanks, where it matures and a sediment settles out.

The proportion of resin to oil varies very considerably, according to the type of varnish we desire to prepare: 25 gal. or 30 gal. of oil to 100 lb. of resin, and about 40 gal. of turpentine, may be taken as a fair average for the best varnishes.



12. ROLLER GRINDING MILL. SIDE VIEW

Spirit Varnishes. These may, or may not, contain a small quantity of oil. If they do contain oil, they are made on the same lines as the oil varnishes. Ordinary spirit varnishes are merely solutions of the resin in spirit. Of course, many of the resins are not sufficiently soluble to give spirit varnishes. Those commonly used are shellac, sanderac, mastic, and common resin.

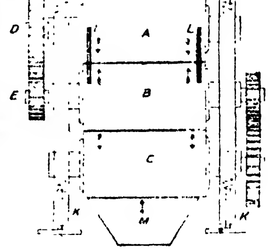


11. VERTICAL MIXER

Lacquers. Common lacquers are usually solutions of shellac in suitable solvents, with the addition of a small quantity of colouring matter, usually an aniline dye. Recently they have been replaced by pyroxylin varnishes, which consist of a solution of pyroxylin [see Guncotton and Celluloid] in amyl acetate, with the addition of a small quantity of resin. These pyroxylin varnishes can also be coloured, and are suitable for lacquering metal, wood, and other substances. They also serve as a medium for the bronze and aluminium paints.

"Galuvos" is a lacquer belonging to this type which has recently been put on the market. It is manufactured in four varieties, three of which are coloured, corresponding to the primary colours red, blue, and yellow, while the fourth is a colourless preparation. By suitable combination of two or three of the primary colours, any desired shade of colour may be obtained, which is then diluted to obtain the required tone by means of the colourless variety. A table has been prepared by the makers, the Metallic Composition Company, showing the proportions required to produce the ordinary shades, thus: three parts of primary yellow and seven of primary blue, give emerald green; or again, four of primary red, eight of primary blue, and eight of primary yellow, give olive green, and so on. The coatings produced are tough and damp-proof, and become extremely hard and resistant after being stoved.

Protective Paints. Asphaltum, which is a native bituminous substance [see Geology], can be used as a black varnish by dissolving it in coal-tar naphtha or turpentine. It is recommended as an anti-corrosive paint for metals, ironwork, bridges, girders, and other structures where iron or steel surfaces are exposed to the atmosphere, and require to be coated with some sort of anti-corrosive paint in order to preserve them from rust. Many different kinds of protective paints have been tried, and a considerable amount of experience accumulated. It is essential that the surface should be clean and dry, as rust has often been found to form underneath a coating of paint. Mill scale, the oxide of iron coating, commonly found on freshly wrought iron and steel,



13. ROLLER GRINDING MILL, VIEWED FROM ABOVE

should also be removed. This is accomplished nowadays by means of a sand blast. It is usual to give the iron a coating of red lead in oil, which of itself appears to possess considerable protective power. But at other times, it apparently fails in its object.

A cheap anti-corrosive coating may be prepared from coal-tar products—that is to say, solutions of coal-tar pitch in coal-tar naphtha. These have been used with some success, but care must be taken that none of the coal-tar acids or crude dead oil [see Coal-tar Products] find their way into the paint. A good anti-corrosive paint, possibly of a similar nature, is now on the market and known as "Siderosthen." A large number of tests have been made in the United States by immersing sheets of metal, coated with anti-corrosive paints, in the waters of Lake Cochituate for several months at a time. From the result of these and other tests, Sabin recommends a varnish in which the proportion of oil to resin is high as the best coating for the protection of steel structures. Pigments can be worked in with such a varnish, producing varnish paints of great beauty and resistant action to the moisture of the atmosphere.

Many of the anti-corrosive paints sold consist of nothing but 90 per cent. of oxide of iron ground in linseed oil.

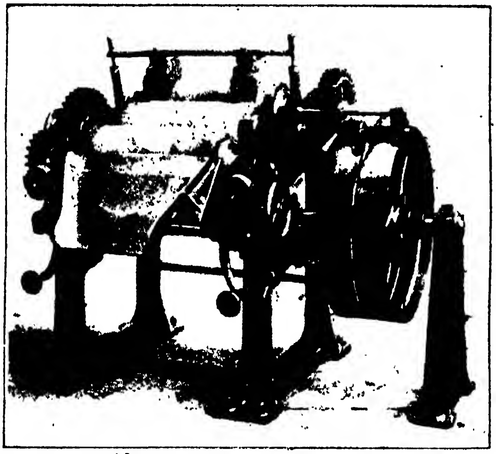
Distempers. These consist of water paints, and the coat is, to a certain extent, water resistant, and therefore washable. The names of the makers of these washable paints are given on page 1036. Such paints are frequently made with casein, the albuminous constituent of milk, and contained in the watery liquor after the removal of the fat. A description of casein is given under "Glues and Adhesives," but we may mention here that casein is itself insoluble in water, and requires the addition of an alkaline substance, such as soda, ammonia, or borax to dissolve it. Where the distemper is sold in the solid form, as powder or paste, the pigment is incorporated with the right proportion of casein and alkali. If, now, the alkali chosen be ammonia, this will gradually diffuse and evaporate into the atmosphere, when the paint is spread in a thin layer over a large surface, leaving the casein behind in the insoluble form. The particles of pigment will thus be knit together by a medium insoluble in water, so that the surface covered by the paint is washable. There are other means of rendering the casein insoluble; thus with slaked lime it gradually sets to a hard water-resistant mass, and these substances may be found in many distempers. The slaked lime, which in the presence of water has helped to dissolve the casein, gradually absorbs carbonic acid from the air, forming calcium carbonate, with the separation of the casein in the insoluble form, just as in the case of the ammonia casein already described.

Various Polishes. Although polishes no doubt protect the surface of wood, or other substances polished, they are more often used to improve the look of the object and give it an attractive appearance.

French polish is made, according to Standage, as follows: $4\frac{1}{2}$ oz. finest shellac is dissolved in 25 oz. of alcohol (96 per cent. strength), 1 oz. of a natural colouring matter, known as dragon's blood, is dissolved separately in 25 oz. of alcohol, and the clear solution poured off from the sediment into the first liquid containing the shellac. The liquids are mixed, $7\frac{3}{4}$ grains of turmeric added, and the whole allowed to stand twenty-four hours, after which it is filtered. Of course, there is as much to be learnt in the method of applying the polish as in making it.

Furniture polish may be made according to the following recipe: 1 oz. of beeswax, $\frac{1}{4}$ oz. of white wax, and 1 oz. of Castile soap, the latter shredded very fine, are heated in a pint of boiling water. When cold, $\frac{1}{2}$ pint of turpentine and $\frac{1}{2}$ pint of spirits are mixed in.

Metal Polish. To brighten the surface of metals, whiting or chalk finely ground is mixed with colcothar (an oxide of iron), and made into a paste with a little soap and oil. Ammonia on a rag will often prove effective in cleaning tarnished brass and other metals.



14. ROLLER GRINDING MILL
(Follows & Bate, Ltd., Manchester)

Boot Polishes. Like all other varnishes and polishes, the primary use of a boot polish should be to preserve the leather underneath. Nowadays, boot polishes are judged by other standards, particularly by the brilliancy of the polish obtainable. This will be better realised when we say that many boot polishes as now manufactured are innocent of any fatty or oily constituent, and frequently contain small quantities of acid, which exert a destructive rather than a preservative action on the leather.

The small quantity of oil contained in the polishes soon loses its effect when boots are worn in wet or snowy weather. The vegetable waxes used in some polishes work well in this respect, but fatty substances interfere with the production of a high polish, and their use is, in consequence, very limited (Andes). All boot polishes must conform to the following essentials:

(*a*) Give as high a polish or shine as possible, when brushed.

(*b*) Be of a good black colour, or else pale transparent hue for brown boo

(*c*) Dry hard, so that the polish will not soil or come off on the clothes.

(*d*) Contain only a small quantity of acid, so as not to destroy the leather.

(*e*) The materials composing the polish must be regularly and uniformly mixed, so that a small quantity of polish will cover a large surface of leather.

Black and Brown Polishes. Boot polishes are largely coloured with aniline dyes. For brown polishes they are almost always used. Lampblack or other animal or vegetable black may be used in compounding "blacking," but as often as not aniline dyes are used, especially such

as have an intense violet colour indistinguishable from black when applied in the form of a polish.

Blacking frequently contains sugar or glucose in some form or another, usually more or less caramelised by treatment with sulphuric acid. Sugar much improves the polish, but the effect soon goes off if too much sugar has been used, as it is "deliquescent"—that is to say, it attracts moisture from the atmosphere. The same considerations apply to glycerin, a not infrequent constituent of polishes.

We cannot do better than give a list of some of the more common constituents of boot polishes and blackings:

Aniline dyes and mineral colours.

Gum arabic.

Swedish tar; coal-tar, and asphalt.

Glycerin.

Animal charcoal, or bone-black substitutes.

Molasses and sugar syrups, grape sugar and starch paste.

Paraffin—spermaceti.

Linseed oils and fish oils.

Shellac.

Lard, stearine, tallow, and other fats.

Turpentine, petroleum jelly, and high-boiling hydrocarbon oils.

Waxes, especially beeswax, carnauba wax, Japan wax and ceresin.

Sulphuric acid, acetate of iron and other chemicals.

The machinery used for incorporating the ingredients are the same or similar to those used in paint manufacture, such as mixers [**9**] and grinding rollers [**14**].

Recipes. In what follows we give recipes from well-known authorities.

BLACKINGS

I.

Beeswax	10 parts	Bone-black ..	5 parts
Spermaceti ..	66 ,,	Prussian blue	2 ..
Turpentine ..	66 ..	Nitrobenzene	1 ..
Asphalt varnish	5 ..	Borax	1 ..

The wax should be melted, and the borax added and stirred in. The spermaceti and asphalt varnish are melted separately, and the turpentine added. After thoroughly stirring, add the wax. Finally add the colour, well rubbed down, and the benzene (Standage).

II.

Bone-black ..	30 parts	Sulphuric acid	1 part
Syrup	15 ,,	Olive oil..	..2 ,,

The black and the syrup are mixed, and the oil added, then the acid, a little at a time. Finally dilute with water to the right consistency (Andes).

III.

Molasses ..	100 parts	Dextrin ..	3·5 parts
Vinegar.. ..	25 ..	Bone-black	30 ,,
Alum	3 ..	Lubricating oil	7·5 ..

This is a German patent, No. 104. 749.

IV.

1·5 parts white wax mixed hot with ·15 parts spermaceti, and 2 parts linseed oil, and 1 part molasses, the mixture kept at 110-120° C., and 1·3 parts of lampblack and 2·8 parts of turpentine added. Finally add a solution of ·02 parts of aniline violet and ·05 parts of shellac in ·35 parts of alcohol.

This polish dries somewhat slowly, but is a better preservative for leather than most other blackings (Nicolet).

V.

Best shellac ..	8 parts	95 per cent. spirit	38 parts
French turpentine	8 ,,	Nigrosine (aniline dye)	½ ,,

The shellac is dissolved in turpentine, and after removal from the fire the nigrosine in spirit is added (Andes).

This is recommended as an excellent varnish for black leather.

VI.

Wax polish prepared according to Brunner ("The Manufacture of Lubricants, Shoe Polishes, etc."):

Yellow wax	50 parts
Oil of turpentine	5 ,,
Potash	10 ,,

These are melted together and treated with sugar, 10 parts; water, 500 parts. The resulting mass is stirred with enough lampblack to colour it deep black.

BOOT CREAMS

I. Brown Cream.

Paraffin..	25,400 parts
Soap....	3,175 ,,
Glue jelly (say, 10 per cent glue) ..	1,815 ,,
Water	6,800 ,,
Oil..	2,050 ,,
Bismarck brown (aniline dye)	70 ,,

Soap and glue are boiled together in water, and the liquid dyed with Bismarck brown, and mixed with the rest.

II. White Cream.

White beeswax	4 parts	Turpentine..	8 parts
Carnauba wax	1 ,,	Water	12 ..
		Potash.. ..	½ ..

If white beeswax be replaced by the ordinary yellow wax, a yellowish cream is obtained. Or by the addition of suitable dyes and soap in the place of potash, brown or black creams can be prepared. Nigrosine is a suitable black dye to use in these mixtures.

Leather Greases. There are a number of preparations which have for their object the rendering of leather soft and supple, with a view to its preservation, and also to render it water resistant

The following formulæ are given by Brunner:

HARNESS GREASE

Soap	2 parts
Sugar	2 ..
Water	1 ..
Potash	1 ,,
Rape oil	20 ..

The other ingredients are dissolved in the water and incorporated with the rape oil by thoroughly stirring in in a gentle heat until the mixture attains uniform consistency.

WATERPROOF GREASE WITH GLOSS

Wax	1 part
Soap	1 ..
Lampblack	3 ..
Oil of turpentine	5 ..
Fish oil	20 ,,

The wax is dissolved in the turpentine by gently warming: the soap is then added in the form of thin shavings: after this, the fish oil, still keeping the mixture warm, and finally the lampblack.

VASELINE GREASE FOR BLACK LEATHER

Vaseline	100 parts
Lampblack..	5 ..
Prussian Blue	5 .

Some of the vaseline is melted and incorporated with the lampblack and Prussian blue in an enamelled iron pan by stirring until a uniform mixture is obtained, and the remainder of the vaseline is added by degrees, keeping the wax stirred all the time.

Continued

VALUING

Occasions Demanding Valuation. Procedure. Preparing the Report. Inwood's Tables with Examples. Setting up in Business

Group 7

AUCTIONEERING AND VALUING

2

Continued from page 4988

By JOHN COX

THE practice of valuation may be said to be the natural concomitant of the auctioneering profession, for the exercise of the one naturally calls for a knowledge of the other. The term valuer in its ordinary acceptation signifies a person who is competent to form a sound opinion as to the value of any conceivable article or commodity, and a like accomplishment in respect of real estate or any interest therein.

It will be seen that the field encompassed is of the widest possible description, and it naturally follows that expert universal knowledge of values cannot possibly be claimed. One finds in practice that there exist valuers who have made a life-long study of the various specialities, and we therefore have competent appraisers of pictures, china, silver, antique furniture, and so on

It may here be said that what we may term the general practitioner should never commit himself to an opinion as to the worth of what he may suspect to be an unusually valuable item. There is a very powerful argument in support of this, for there is a fashion which governs the market price of articles of vertu as in other commodities; and as the paintings, statuary, or what not of a particular master are to-day sought after, so the public taste periodically inclines in quite a different direction.

As an instance of the diversity in values, when dealing with pictures at a recent sale, "The Standard Bearer," by Meissonier, which had sold in 1877 for £787, realised £2,625; while Gainsborough's "Duchess of Grafton," a small oval which had sold in 1884 for £556, only realised a hundred guineas. Again, Landseer's "Prize Calf," which sold in 1863 for £1,890, hammered to only £1,438 when offered two years later, and in 1901 fetched but £441. Similarly, Millais' "Cuckoo," which in 1884 brought £1,995, was valued at but £1,627 10s. seventeen years later.

One might multiply such instances indefinitely, but the foregoing will prove conclusively that the prices of yesterday are scarcely any criterion of the prices to-morrow. As a general rule, therefore, it is the wiser policy to consult the opinion of a specialist in the matter of values of subjects which may be suspected of extraordinary worth.

Occasions Requiring Valuation. We may here consider the occasions for a valuation and the purpose for which one may be required.

PROBATE VALUATIONS. Probate valuations, which are, perhaps, the most common, are called for on the proving of a will. The whole of the real and personal property of a deceased, not entailed, are comprised in the probate valuation, the purpose being that the succession duty may be properly assessed.

MORTGAGE PURPOSES. Before advancing funds upon mortgage it is usual to retain the services of a valuer, who must report fully as to the worth of the proposed security. The greatest care is called for in these matters, because a valuer renders himself liable to an action should the mortgagor default, and the property, upon being sold, fall short of realising the amount lent upon it, if, indeed, it can be shown that the funds were advanced upon the strength of an exaggerated valuation.

PARTITION. In splitting up portions of an estate for succession or other purposes.

LANDLORD AND TENANT. The valuing in of a tenant who takes trade or farming stock and fixtures, growing crops, and the like, from an outgoing party, is usually carried out by the appointment of two valuers, one employed by the incomer and the other by the outgoer. The inventory having been taken, the valuers meet upon the property and agree as to the price to be paid or allowed.

COMPENSATION, OR COMPULSORY ACQUIREMENT PURPOSES. Upon the taking of any lands or hereditaments by a railway or other undertaking, the service of a notice to treat under Parliamentary powers is the opening of the negotiations. The party upon whom the notice is served instructs a valuer, who proceeds to appraise the property to be acquired in the ordinary way, with the exception that the valuation is increased by the addition of 10 per cent. thereof for "forced sale" or severance of the interest. The valuer's fees in these cases are paid by the body taking the property.

DILAPIDATIONS. A valuation of dilapidations is very often called for in the case of the termination of furnished house lettings.

Valuation of Portable Property. It would hardly be possible to lay down directions for the process of valuing portable property; but it is sufficient for the moment that the lines upon which the valuation is carried out be indicated.

Firstly, then, as concerns such property as household furniture, the valuer must draw upon his auction-room experience for aid. It will be found that a very short but intimate acquaintance with auction sales will give one a very useful insight into the values of everyday articles, but it is obviously impossible to place old heads upon young shoulders in these matters. It should be understood that, as a general rule, the value of an article is what it will fetch in the open market—that is, the "auction price." The valuer does not, except in specialised articles, concern himself with a fancy value, but deals strictly with intrinsic worth, relying solely on his knowledge of the markets. It is the practice on every occasion to make an inventory of the goods with the values set down in the proper column of the inventory book, a character or private mark being usually employed. The inventory is summarised at the end of the entry, as follows:

Furniture	£
Statuary and ornaments..	£
Silver and plated ware ..	£
China and glass	£
Wines	£

A report as to the value is then prepared in the following form:

re T. Richards, Esq., Decd.

VALUATION for Estate Duty of the Furniture & General Effects in and upon the premises known as "The Manse," Caterham Valley, Surrey, late the property of Thomas Richards Esq., Decd.

SUMMARY

Furniture, Statuary, Ornaments and General Effects	£2,817	14	0
Silver & plated ware	492	6	0
Jewellery	890	0	0
China & Glass	89	10	0
Wines	450	0	0
Horses, Carriages, Live & Dead Stock	312	0	0
	£5,051	10	0

LONDON, May 2nd, 1906.

The above, more particularly enumerated in an Inventory made this day, are valued for the purpose of Estate Duty at the sum of Five thousand and fifty one pounds ten shillings.

ED. JAS. CARPENTER,
Auctioneer, &c.,
£5,051 10 0. 680, *Barbican, E.C.*

Valuation of Real Estate. We now arrive at a branch of valuation which is capable of being dealt with upon established principles—namely, the valuation of real property. Apart from local factors, which favourably or otherwise operate upon values, we here call into use the valuation tables, more commonly referred to as *Inwood's Tables*.

These tables are a collection of ascertained numbers, showing the number of years' purchase of a net annual income arising from a property, and which may be given for that property, in order that a purchaser may receive a fixed rate of interest, together with the return of his capital within the period during which the property or his interest in it shall endure. A reference to the tables will show that they apply to certain and uncertain interests, to the value of an interest in reversion, to the amount of premium payable for a lapsed lease, and so on.

In beginning a valuation, the prime factor is contained in the answer to the question: What is the net annual income a purchaser will get from the property under notice? The answers, then, to the following questions will form the groundwork of any valuation:

(1) What is the nature of the interest I am valuing?

(2) What amount will the purchaser receive?

(3) For how long will his interest endure?

(4) What rate of interest must he have?

(5) How long—if at all—will it be before he begins to take his income?

(6) What is the present value of any capital amount he may have to pay in respect of which allowance must be made?

(7) Is the condition of the property such that from the valuation must be deducted a stated sum to be expended on the property forthwith before it can be expected to return a proper revenue?

(8) In what degree does the law of supply and demand operate upon the interest?

Having given due consideration to these factors, the valuer must consider under what percentage of return he must make his calculations, and as regards the rates the table on this page will be found generally applicable. One often deals with the values of weekly class property, and in arriving at the net annual income, we give a table which will be useful:

PROPORTIONS OF OUTGOINGS TO RACK RENT

Ground rent	⅛th to $\frac{1}{10}$th	
Insurance	1s. 6d. to 2s. 6d.% on value of building	
Land and other taxes ..		2½%
Repairs, average annual ..		10 %
Rates and Taxes:		
House Duty	4 %	
Poor Rate	12 %	
Consolidated and General Rate	7½%	
Water Rate	5 %	
		28½%
Contingencies, say ..	5 %	
Management	5 %	
		10 %
		Say, about 50 % of gross rent

MARKET RATES OF INTEREST

Class	Interest	Years' purchase	Reason for Stated Interest
Agricultural land	3% to 3½%	33 to 28	Safe security, sought by wealthy persons for the social position it gives. It is, as a rule, underlet, and will increase in value
Accommodation land	4%	25	
Ripe building land	5%	20	
Ground rents, well secured freehold	3%	33	These sell to pay the stated rates of interest because of the security being from five to ten times covered, and the investment increases yearly in value.
Do. other freehold	3½%	27½	
Do. leasehold ..	4% to 5%		
Freehold houses: Superior	4% to 5%	25 to 20	Sell to pay the stated rates because the security is not, like leaseholds, subject to vexatious repairing covenants and depreciation in length of holding.
Inferior	7% to 9%	14 to 11	
Leasehold houses: Superior	5% to 7%	20 to 14	Outgoings to be paid, let or not. Restriction from free dealings. Limited nature of the interest.
Inferior	8% to 10%	12 to 10	

By "compounding" for the payment of rates an owner may save from 30 per cent. to 25 per cent. of them.

Inwood's Tables. Turning to Inwood's tables, we will briefly refer to the uses to which the more important of them are put. Table 1, it will be seen, enables one to value a lease or property for any number of years at rates of from 3 per cent. to 10 per cent. interest. Thus, a lease for 50 years to make 7 per cent., and to get back the principal is worth 13·801 years' purchase of the net annual income.

Table 2 enables the valuer to ascertain the number of years' purchase he may give for an interest secured by a life deduced from mortality observations made at Northampton. Thus, a

lease or annuity to endure for the term of a certain "life" may be valued by means of calculating on a person's present age. For example, an interest secured on a life aged 20, to show 6 per cent., is worth 12·398 years' purchase of the annual net income.

Table 3 is substantially the same as Table 2, but is based upon deductions made at Carlisle. On this table, the interest last referred to would be worth 13·835 years' purchase, because the Carlisle rate of mortality is not so great as that of Northampton.

Table 4 shows the present value of £1, due at the end of any number of years, expectant upon the death of a person of any age.

The tables then follow on, dealing with various contingencies, until we reach the next most useful one—Table 17—which shows the present value of a reversion to a perpetuity after the expiration of any number of years not exceeding 60. It may be noted that any interest deferred a greater period than 60 years is not considered valuable. This table is used in valuing freehold ground rents where the reversion to the rack rents is getting considerable. [See example.]

Smart's Tables. Upon somewhat similar lines the tables proceed to deal with the value of reversions to perpetuities secured upon various lives. Smart's five tables of compound interest are then given, and these are of very great assistance to the valuer.

The first table shows the amount which £1 will make if put out to interest at the several rates of percentage for any number of years. It will be clear that this table enables the valuer to calculate the immediate capital outlay necessary to provide for a contingency at the expiration of any period. For example, if we buy a house for £500, the lease of which will fall in in 60 years, and desire, by making a payment now, to secure the return of £500 in 60 years, we find that £1 invested now at 3 per cent. compound interest equals 5·89 in 60 years.

Therefore, £500 ÷ 5·89 will equal the amount required to be laid out now to return the capital at the end of the period.

The second table treats with the present value of £1 due at the end of any number of years. For example, if we know that at the end of 20 years we shall have to pay a premium of £100 for the renewal of a lease, we know by reference that the amount to be deducted from the present value of a property with such a condition attaching to its purchase will be, on the 4 per cent. table, £100 × ·4564 = £45·64.

The third table shows the amount of £1 per annum in any number of years. For example, suppose we have a leasehold house with an unexpired term of 80 years, and desire to put by an annual sum which will return the amount we paid for it, say £500, when the lease falls in, we see that if we put by £1 per annum at 3 per cent. interest we shall have £321·36 at the end of 80 years, so that £500 ÷ 321·36 will show the exact annual amount to be laid by.

The fourth table shows the present value of £1 per annum for any number of years. This table is practically identical with Inwood's Table 1, and shows what amount must be paid for the stated income at the required rates of percentage.

The fifth table shows the annuity which £1 will purchase for any number of years. Thus, a lessee taking premises at £100 a year on a lease for 21 years pays a premium of £300, and desires to know the annual amount at which he "sits," or his sitting rent. If he were to lay by his £500 at 5 per cent. interest for 21 years he would be getting £·0780 per annum for each £1, so that he pays, in fact, in each year £·0780 × 300, in addition to his rental of £100, or in all, £123·4 per annum.

We need not, for our present purpose, pursue the tables further, but will conclude with a few brief examples, which may serve to show the method of getting out the values of properties more ordinarily met with, following our rule always to arrive at the net annual income, and carefully settling the rate of interest.

EXAMPLES

Value 20 acres of freehold agricultural land letting at £2 per acre per annum.

3 PER CENT. TABLE.

20 × 2 = £40, net annual income.
40 × 33·333 = 1333·32

or £1,333 6 8

Value 20 acres of accommodation land, letting at £4 per acre per annum. There is a tithe rent charge of £5 per annum on the whole.

4 PER CENT. TABLE.

20 × 4 = 80. £80 = the gross annual income.

Deduct tithe rent charge 5

£75 = net annual income.

75 × 25 = £1,875.

Value, say, 12½ acres of ripe building land situate on the borders of a rapidly rising town, and possessing a main and parish road with available building frontages of 3,000 ft.

This may be taken all round at £5 per foot frontage, it being safe to assume that a plot of 30 ft. frontage would let at £7 10s. per plot ground rent, thus showing a 5 per cent. investment, so that we have:

3,000 × 5 = £15,000.

What is the fee simple, or freehold value per acre of land which for ten years will remain agricultural land worth a rental of 30s. per acre per annum, for the second ten years will be accomodation land worth £3 per acre per annum, and after that time will be ripe for building operations and command a ground rent of £10 per acre per annum? It will be ten years before the whole of the land is developed and the full ground rent secured.

Here we see that a purchaser would get out of the agricultural land £1 10s. per acre for ten years:

	Value per acre.
AGRICULTURAL LAND, 3 PER CENT.	
£1 10s. per acre per annum for 10 years = 1·5 × 8·530 years' purchase = 12·795, or, say	£12 15 0
Next we have	
ACCOMMODATION LAND, 4 PER CENT.	
£3 per acre per annum for 10 after 10 years [see note below] = 3 × 5·479 = 16·437, or, say	16 10 0
We have now disposed of the matter so far as regards 20 years of the period, and we now come to	
SECURED FREEHOLD GROUND RENTS, 3½ PER CENT.	
We see that a purchaser will be getting not £10 per acre at once, but *at the end of*	
Forward	29 5 0

Forward £29 5 0

10 after 20 years. The average annual income for the period must be deduced. This is arrived at as follows:

For the	1st year $\frac{1}{10}$ of	£10	=	£1
„	2nd year $\frac{2}{10}$ of	10	=	2
„	3rd year $\frac{3}{10}$ of	10		3
„	4th year $\frac{4}{10}$ of	10	=	4
„	5th year $\frac{5}{10}$ of	10	=	5
„	6th year $\frac{6}{10}$ of	10	=	6
„	7th year $\frac{7}{10}$ of	10	=	7
„	8th year $\frac{8}{10}$ of	10	=	8
„	9th year $\frac{9}{10}$ of	10	=	9
„	10th year a whole	10	=	10
	Total			£55

55 ÷ 10 = 5·5 or £5 10s., being the average annual ground rent for the term. £5 10s. per annum for 10 after 20 years = 5·5 × 4·180 years' purchase = 22·99, or 23 0 0

Lastly, after the lapse of 30 years the purchaser begins to receive the full ground rent per acre, so that:

Secured Freehold Ground Rents, 3½ Per Cent.

£10 per annum, full annual ground rent, in perpetuity after 30 years = 10 × 10·179 years' purchase 101·79, or, say 102 0 0

So that the present value of the land is per acre .. £154 5 0

The method of getting out the year's purchase for a term after a term is by taking the year purchase equivalent to the sum of the period and deducting therefrom the equivalent of the greater of the periods. For instance, in the first of the above-mentioned we have 10 after 10 years. On the 4 per cent. Table, the equivalent of the sum of the two, that is

20, is	13·590	years' purchase
and 10 years on the same table is	8·111	„ „
Deducting, we get the equivalent of 10 after 10	5·479	„ „

The method is the same in the other instances.

Value a freehold ground rent of £50 per annum abundantly secured upon well-built property in the Strand, London, of a present annual value of £600 per annum, with reversion to the rack rents in 90 years.

Here we have an excellent security, and value simply upon the 3 per cent. Table.

50 × 33·333 = 1666·65, or, say .. £1,666 10 0

Where, however, a freehold ground rent has its reversion to the rack rents in a less period than 60 years the reversion is a considerable factor. The ground rent is valued first as a well-secured income for a term, with the addition of the reversionary value. Say, for example, if in the foregoing instance the reversion to the rack rent were distant but 10 years, the working would be:

Well-secured Freehold Ground Rent, 3 Per Cent.

£50 per annum for 10 years = 50 × 8·530 = 426·5, or, say £426 10 0

Although in ordinary instances we should treat the reversion upon the 5 per cent. Table, yet here we have such an exceptionally fine reversion that we deal with it upon the 4 per cent. Table.

Forward £426 10 0

Freehold Property, 4 Per Cent.

Rack rent £600 per annum in perpetuity after 10 years = 600 × 16·889 years' purchase = 10133·4, or, say .. 10,133 10 0

Full value £10,560 0 0

Value an income arising out of a property held for 60 years at a head rent of £2 and underleased for the full term, less one day, at £20 per annum.

Leasehold Ground Rent, 5 Per Cent.

£20 – £2 head rent = £18. 18 × 18·929 = 340·722, or, say £340 15 0

Where the interest is shorter the table used is higher, this class of security selling to pay from 5 per cent. to 9 per cent. according to the duration of the interest.

Where the property is not underleased for the full term the reversion, if less than 60 years distant, is taken into account, and valued upon the selected table at the full net rental, after the term for which it is underleased, the years' purchase being made out as previously shown.

Value a well-built freehold house let upon a three years' agreement at £60 per annum, situate in an established London suburb.

Here we have to take the gross rental, and make deductions for contingencies:

Gross value		£60	0 0
Allow:			
For repairs, 10 per cent.,	£6		
„ empties, one quarter's rent in every 3 years, per annum ..	£5	11	0 0
Net income.. ..		49	0 0

We value upon the 6 per cent. Table, and have 49 × 16·667 = 816·683, or, say, £816 10 0

The procedure in the case of a leasehold house would be, assuming that the property were let at £60 per annum, but that there were a ground rent of £10 with a term of 55 years to run:

Leasehold House Property, 7 Per Cent.

Gross value		£60	0 0
Allow:			
Ground rent ..	£10		
Outgoings as before	11	21	0 0
		39	0 0

Net annual income £39 for 55 years = 39 × 13·940 = 543·972, or, say .. £544 0 0

Where such a contingency as the putting into repair of a property, the payment of road-making charges, and so on, necessitating an immediate capital outlay, has to be provided for, a deduction is made from the amount of the valuation of a sum estimated to be sufficient to cover the outlay.

The above examples should have made sufficiently clear the lines upon which the correct valuation of the interests more ordinarily met with should be conducted. The main points to be borne in mind are, as we have already said, what the purchaser is to receive, and if he will have to make provision for an immediate or distant contingency, the occasion for which he has a knowledge at the time he appraises the worth.

On the next page we give a form of the "Report as to the Value" which is usually adopted.

A REPORT as to the VALUE of certain property known as 13, 15, 17, 19, *&* 21, *Bank Parade, North Hampstead, in the County of London, and made for the purpose of mortgage.*

The above property, which is FREEHOLD, is situate in a well-established market position, adjacent to two Railway Stations and the terminus of the electric tramway route. A station on a new underground railway is in course of erection upon the site of Nos. 23 *&* 25, *Bank Parade.*

The property is of very sound construction, the present condition is excellent, the tenants well established, and all of them hold upon full repairing leases for long terms at the following rentals:

No. 13. *J. Scott, Family Butcher*	*@*	£160 *p.a.*
,, 15. *Amalgamated Dairies Coy.*	,,	150 ,,
,, 17. *Pacific Bank (Hampstead Branch)*	,,	130 ,,
Nos. 19 *&* 21. *J. Barnes, General Draper*	,,	260 ,,
Total Rental	..	£700 ..

REPORT

We have fully inspected the above described property together with the Leases under which the tenants hold, and are of the opinion that the value of the fee simple is FOURTEEN THOUSAND POUNDS. The tenants, we find, all covenant for an increased rent within a period of five years, and the value will therefore proportionately increase.

HATTON JONES & COY.,
444, *Fleet Street,*
£14,000 0 0 *London, E.C.*

Fees. We give a scale of fees applicable to valuations:

For valuations of furniture, fixtures or other effects, 5 per cent. up to £500, and 2½ per cent. on the residue.

Valuations of furniture and effects for probate purposes, 2½ per cent. on the first £100 and 1½ per cent. on the residue.

Valuation of properties, 1 per cent. up to £1,000, 5s. per cent. beyond on the full amount of the valuation. In valuations for mortgage purposes, if an advance be not made, one-third of the above scale, the minimum fee to be £3 3s.

In Business as an Auctioneer and Valuer. As with other professions necessitating the building up of a connection, so with that of an auctioneer and valuer. It is manifestly unwise to start without a tolerable balance at the bank and a goodly number of personal acquaintances who, through themselves and their friends, would be able to lend support to one's venture. We should advise our pupil to endeavour, as far as possible, to limit the area of his early engagements to his immediate locality. The difficulty is always to find a suitable opening, and this is increasing year by year.

Auctioneering—and its associated branches, valuing, estate agency and surveying—being the many-sided vocation it is, always seems to be one which lends itself readily to being followed in partnership. During the latter portion of one's employment with firms, one is fairly certain of forming an acquaintance which may ripen into a business arrangement in later years. We would say, then, seek a competent partner with whom there is a fair probability of mutual agreement, settle the departments which each is to take, and, having chosen an opening, begin to found a business upon the lines which experience has taught are the right ones.

Where to Start. As regards locality, we cannot counsel the beginning of operations in the more confined portions of London, for the reason that such districts seem to have well-established local practitioners; and unless one happens to come across some, say, estate agency business, which will serve as a nucleus and a support to the sister profession, it would be far better to seek a developing locality, and to take one's chance there.

Given the right position, a reasonable amount of financial backing, and a good, sound knowledge of the business, crowded though the profession undoubtedly is, a soundly managed concern will prosper.

The endeavour should be to found a connection, and it must be acknowledged that, as a rule, auctioneering as a profession in itself will not answer, but it is well supplemented by the estate agency and valuing branches; the latter will "feed" the former, and should be fostered accordingly. It must be borne in mind that unless one is fortunate enough to be well supported by solicitors and others having need of the frequent service of an auctioneer, sales by auction are not sufficiently numerous for the branch to be carried on by itself.

The Office. Having determined the position, the offices should be well decorated, and furnished solidly and usefully. Prominent professionally-worded notices should be displayed, and if sale rooms are an annexe, the fact should be brought to the notice of the locality. Possibly the systematic circularising of the neighbourhood—personally addressed letters to residents—may serve as a good introduction, and we think that well-displayed, neatly written poster boards are to be recommended. One must be careful not to approach anything in the nature of the "cheap-jack" style of business, for advertising in the auctioneer's calling should be done in "professional" style. Without amplifying this too much, we would instance the manner in which the names of certain firms in various localities seem to preponderate over others.

In perhaps few vocations does the personality of the principal so largely affect the success of a business as that of an auctioneer. He must be courteous and obliging, polite and painstaking to all; and if he endeavours to form friendships upon the strength of his personality and business knowledge, he is fairly certain to prosper where his apathetic and unapproachable brother professional would lack support. Deal briskly with all matters entrusted to the firm, and let it be known that affairs are properly handled in the office. Difficult as it may appear of accomplishment, endeavour to please all, and it is quite possible to become, in the course of time, a well-sought-after professional man.

AUCTIONEERING AND VALUING *concluded; followed by* ESTATE AGENCY

Group 19
PRINTING
2

Continued from page 5028

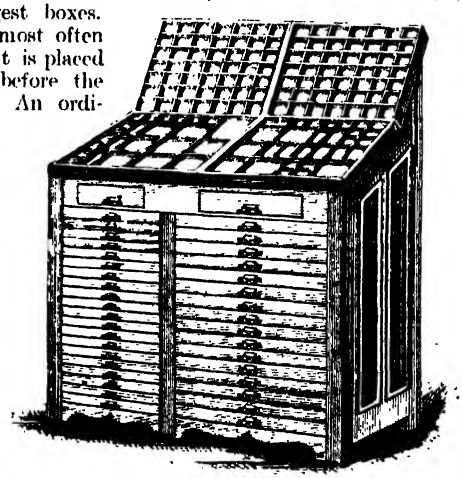
THE WORK OF THE COMPOSITOR

The "Lay" of the Case. The Tools Used in Setting and Correcting Type. Spacing. Punctuation. Paging. Inserting Notes

By W. S. MURPHY

WE have now got our type and spaces, and must next learn where to put them and how to use them. The type is kept in shallow wooden trays, called *cases*. For a full fount of type a pair of cases is needed, the one to hold the small letters (called the *lower case*), the other the capitals, small capitals, figures, etc. (called the *upper case*). The cases are divided by strips of wood into small partitions or boxes, the lower case having 53 boxes and the upper case 98, as shown in 2.

The Lower Case. There are several particulars requiring special attention here. You see that the lower case is divided into boxes of different sizes, and that the letters do not lie in alphabetical order. Two principles have dictated the form of the case. The compositor, when at work, stands at the centre of the case, which is on the top of the frame [1]; therefore, the letters most in use should be nearest his hand and line of vision, and also occupy the largest boxes. The letter "e" occurs most often in English words, and so it is placed in a large box, right before the eye of the compositor. An ordinary full case contains, roughly, 2 lb. of "e," and about 4 oz. of "x" and "z." The second principle takes account of the fact that English, being an uninflected language, contains a number of small and constantly recurring words, such as "the," "and," "of," "is," "that," "no," and "not," and the letters composing these words are placed in juxtaposition. The beginner could not do better than learn to point out rapidly the boxes which make up those words; the lesson is easy, and yet of great help in learning the boxes.



1. CASE FRAME

The Upper Case. The arrangement of the upper case is essentially simple, so far as the alphabet of both capital and small capital letters are concerned. Each letter follows in regular order, with the exception of U and J. In 2 the lay of the "book" case is given, and here a divergence occurs between the practice in most newspaper offices and book offices. Instead of the caps ranging in regular sequence from the top of the left-hand, and the small caps from the top of the right-hand division of the case, the news-man finds his capitals in the four lines of boxes at the bottom of the right-hand division of the case [3]. This, however, is a matter of office practice. A compositor trained in Glasgow is accustomed to a lay of case different, in very important respects, from those used in London. The figures in the standard Scottish case range along the head of the lower-case, and the spaces are grouped round the full-point box. The compositor must learn to think of letters as the component parts of words, not in the order of the alphabet, and once he has acquired that habit, no arrangement of letters in the cases will present any difficulty.

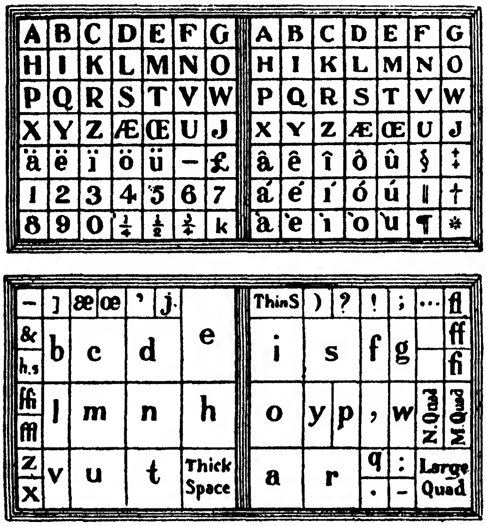
Before leaving the cases, we would add a word of advice. The student should carefully note the position of accents, signs, and reference points, and keep them in order, because, being seldom used, they are apt to slip into confusion, and much time is thereby lost.

The Italics. Next in importance is the *italic* case. Where a large quantity of italic is used, the letter is laid in a pair of cases, like the ordinary founts: but for small offices, or light founts, a form of italic case has been devised which carries the whole fount in one case. Two-thirds of the area to the left is the lower-case, laid like an ordinary large lower-case, the third to the right being the upper case. This is a handy form of case, and is much used for small founts of fancy and jobbing type [4].

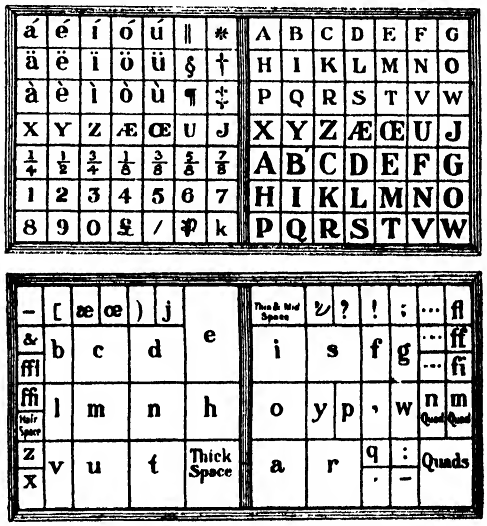
The *frame* [1] on which our cases stand contains eight pairs of cases, shelved one above the other. Frames are all of the same structure, height, and width; but there are single frames, whole frames, and double frames. The form of single and double frames is obvious; the whole frame has an extension equal to half the case rack, the under part of which is a kind of cupboard, and the upper part a shelf, useful for holding the compositor's stores of various kinds.

Compositor's Implements. The personal equipment of the compositor is a very light one. Some of his tools are provided for him. Every self-respecting compositor, however, provides himself with at least two composing-sticks [5], a set of brass setting-rules [6], a bodkin [7], a pair of shears, and tweezers [8].

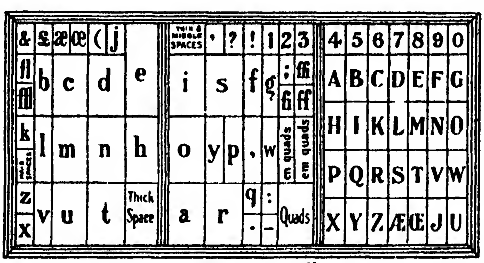
The Composing-stick. The *composing-stick* commonly used in book-work is made of iron; it is flat, 8½ in. long, 2 in. broad, rimmed on end and back by a band half an inch deep and fitted with a movable bar, set at right angles with the back and parallel with the end and fixed by screw or clip at any point in the length of the stick. The type is set between the movable bar and the end rim, the bar being fixed at the breadth to be set. News setting-sticks are sometimes made of solid mahogany, with the column-breadth cut out and lined with brass. Large setting-sticks, usually made of wood, for bills and wide measures, are supplied by the "house." Brass *setting-rules* are slips of brass, type high, nosed at the end, cut to pica ems, from 2 ems upwards, and are used to give a smooth surface on which to slip the type and assist in lifting it when the stick is full. *Bodkin* and *tweezers* assist the compositor when making corrections or alterations in the type after it has been set.



2. OLD-FASHIONED BOOK-WORK CASE



3. FAST NEWS-WORK CASE



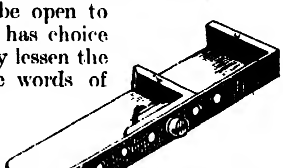
4. JOBBING "HALF" CASE

Attacking the Copy. We assume that our young compositor has mastered the fount and the boxes, and is ready to take up "copy." A compositor's copy is the manuscript to be printed. Typewritten copy is very common, but handwriting is still to be read in book offices, and even more frequently in news offices. If the copy looks bad, it is a wise plan to study the style of the writing for a few minutes. You may take it as certain that an educated man always uses the same sign for every word or letter, and once you get into the secret of his style, difficulty, for the most part, vanishes. Now fix the copy on the section of the upper-case most convenient, and begin. Hold the setting-stick in the palm of the left hand, lightly clasping it with the four fingers, leaving the thumb to play free [9]. Take a few words of the copy into your memory; pick up the letters one by one, and place them, nicks outward, into the setting-stick, holding each one as it comes lightly with the tip of the left-hand thumb. Put in a space.

How to Get Up Speed in Setting. Simple as that action looks, it involves a great deal. The compositor should stand erect, shoulders straight, head well poised, arms moving freely from the elbow to wrist. He should never try to read his copy and pick up letters at the same time; half a dozen words or a phrase may be taken into the memory at once, and at the spacing of the last word the eye is free to return to the copy. When picking up letters the eye should direct the fingers; the letter to be picked up is seen, and its angle of position observed; it is picked up so that it drops face upward, nicks outward, into the stick. A straight line is the shortest distance between two points; the lifting hand should go straight to the setting-stick. The distance can be lessened by letting the setting-stick follow the lifting hand. Observation of these directions saves the compositor from falling into bad habits and tricks of style that waste time and energy. Some compositors twirl the type after it is in their fingers; others make sweeping curves in bringing the letter to the setting-stick, and many have worse habits. Every unnecessary action is lost time and energy. The ideal compositor is an intelligent automaton; his brain thinks; his eyes,

fingers, hands, and arms move with mechanical regularity and accuracy.

Composing—a Work of Art. A book is a work of art. It is not enough that the words be made readable. In the plainest book the lines must all be of equal length, and the spaces between the words as regular as possible. The space commonly put between words, to separate them from each other, is the thick space. When, near the end of a line, the compositor finds he has a space too small for the next word, one of three courses may be open to him, or perhaps he has choice of all three. He may lessen the spaces between the words of the line, and get in the word; he may enlarge the spaces between the words and fill up the line; or he may divide the word, putting in the first syllable, with a hyphen. Dividing words should be avoided, wherever possible. It is a good rule to double rather than halve the space between the words. Words irregularly spaced, and lines widely spaced coming close after lines spaced thinly, present an unsightly appearance. As the compositor is provided with spaces finely graded—with the hair-space, and spaces of hair-line gradation—he has no excuse for making bad work.



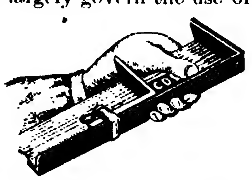
5. COMPOSING-STICK

6. SETTING RULE

Indention and the use of capitals are subject to general rules; but individual taste has considerable play. To *indent* is to shorten the line at the beginning by a space. The first line of a paragraph is commonly indented. In short breadths the indention is 1 em, and for broad measures it runs from $1\frac{1}{2}$ ems up to 3 ems. Reverse indention—that is, the shortening of the second or following lines—occurs in certain forms of verse, special quotations, and tabular matter.

The general rule for the use of *capitals* is: First letter of the first word in every sentence, proper names, prefixed titles and degrees, names and titles of Deity. Office style, and the taste of the author or editor, largely govern the use of capitals. Carlyle, for example, insisted on capitals to the verge of bad taste.

Spelling. It is an essential part of a compositor's mental equipment that he should be able to spell correctly the words most commonly used in literary English. The compositor's product is words, lines of words, paragraphs of words, and pages of words, and he ought to know the form and appearance of the things he builds. If he studies the look of words, the compositor will readily see when a word is rightly or wrongly spelt.



9. METHOD OF HOLDING THE COMPOSING-STICK

Punctuation. The subject of punctuation seems thorny with difficulties, and is a complex one. Yet a great many compositors who could make neither head nor tail of the elaborate rules given in manuals of English composition punctuate almost perfectly. Punctuation marks may be classed in two divisions—breathing marks and tone marks. Comma, semicolon, and period are marks of silent breathing, or pause; colon, dash, parenthesis, bracket, interrogation, and exclamation, denote change of tone. Again, in grammar, punctuation indicates the partition and nature of the sentence. The comma marks the divisions of the sentence directly related to the main predicate or verb; the semicolon separates the qualifying contrary, or adversative addition to the main proposition, generally having a predicate of its own; the colon denotes equality between two or more sentences, closely connected, and related to one idea, or parts of one proposition; the dash marks a break in the continuity of the sentence, a transition, ellipsis, explanatory clause, or parenthesis; marks of parenthesis enclose words, phrases, or sentences, thrown in for additional elucidation but having no part in the grammatical structure of the sentence; brackets are sometimes used as parentheses, and to mark the outside of a double parenthesis, but more frequently to distinguish a sentence equivalent to a footnote in the text. The period, interrogation, and exclamation points, hyphen, apostrophe, 2-em and 3-em dash, leaders, and braces, yet remain. The full-point or period marks the end of a sentence, and is used as the sign of abbreviation; interrogation and exclamation points explain themselves; the hyphen serves to join compounded words which custom has not made one, and marks the break of a word at the end of a line; the apostrophe denotes the possessive case, shortened words, especially in dialect, and, used either in single or double form, serves to indicate the end of quotations; the 2-em dash is used to finish a broken-off sentence; the 3-em dash, leader, and braces seldom appear in ordinary text.

7. BODKIN

8. TWEEZERS

For literary, rhetorical, or pictorial reasons, the author of book or placard may elect to restrict the number of commas to the lowest limit, insert dashes where colons would suit the structure of the sentence better, or make semicolons of periods; but with all that the compositor has little concern—his duty is then to follow copy blindly. We have given here the punctuation most generally adopted by practical printers, apart from all theories on the subject.

The Slip-galley. When the compositor's setting-stick is full, he lifts the type carefully out, and lays it on a slip-galley. This is a frame of brass with zinc bottom, like a long picture frame, with one narrow end out. There are other kinds of galleys, some square, some with only two

sides framed, some solid brass, and some wood; but the use of all is to hold type which has been set. After the galley has been filled with lines of type it is taken away to another part of the establishment, which we shall visit soon, and comes back accompanied by a corrected first-proof. The reader has read the proof, and marked the errors. The compositor lays the galley on his frame, and begins the work of correcting. Where it is a mere change of a letter of similar breadth, or the turning of a letter, no difficulty occurs; but, unfortunately, our beginner does not set so carefully as that. If the letters to go in and the letters to come out differ in the least—and this is nearly always the case—the spacing must be carefully readjusted. When the corrections are specially heavy, such as omissions of words or phrases, the corrector should take line after line into his setting-stick and run over from line to line till all is made square again.

Making Up the Page. We will suppose that the revise proof has been successfully passed, and that the type is ready for paging. No rules can be given which will afford a guide to the sizes of pages, chapter headings, page headings, and such particulars, for practice has outrun all rule. Having acted according to instructions in these particulars, the compositor must carefully gauge the length of the page, and make up to size. The length of the page includes page numbers and headings; but in addition a line of quadrats should be run along the foot of the page to protect the type and afford a basis for the sheet signature. Two safe rules may be given: no page should begin with a broken line from a paragraph in the page preceding, nor should a chapter heading or full-line sub-heading come at the bottom of a page.

When the page is made up, it is corded. Page-cord is a strong twine made for the purpose, and it is given out in lengths suitable for the various sizes of pages. Fix the end of the cord on the end of the last line, and pull the cord firmly round the page, winding it four or five times round, drawing gradually tighter, and slip the end of the cord between the cords and the type at a corner, fixing it firmly. If the page has been well set, it will now lift like a solid slab, and slide easily on to the imposing table.

Sidenotes and Footnotes. Sidenotes, footnotes, and cut-in notes are used for commentaries, summaries, or other additions to the text. *Sidenotes* generally lie on the margin of the page, and are set in types three removes smaller than the body of the page. Small in width, these notes require to be carefully set, and placed exactly in line with the passage to which they refer. *Footnotes,* so named because they are placed at the foot of the page, involve the reference marks, *, †, etc. The asterisk is set in the body of the type, at the point to which the first, or only, reference is made, and a corresponding asterisk begins the footnote. The second reference is similarly marked by daggers, and so on. If there are more notes than reference marks in the fount, then they are doubled, thus making reference easy. *Cut-in notes* present difficulties. Of course, before the type is set these notes should be given in full with the copy. Where there is a cut-in note, the compositor must shorten his line by the breadth and margin of the note. The best way is to set the note first, justify it to the size of the type of which the text is composed, and fill in the short lines.

Making Even. The directions given above refer mainly to bookwork, because the book still remains the staple product of the printer. Hand-setting practice is nearly the same in all branches of the trade. The news compositor gets smaller pieces of copy, and must learn to *make even.* That is to say, instead of ending with a paragraph, the last line of which he fills up with quadrats, showing the short line seen in all books, he must make his last word end a line. This requires foresight and clever craft, only to be acquired by practice. Display of advertisements, colour-work, posters, handbills, circulars, etc., belong to the commercial and jobbing department, directions for which are given in a special section.

Cleaning and Distributing Type. When a job has been worked off on the press or machine, or has been stereotyped, and is no longer required, the type is cleaned and put back into the cases for further use. A fairly strong solution of potash, well brushed into the type, followed by a thorough rinsing with water, gives the cleanest result. Washing done, the forme—as the page or pages of type placed in an iron frame, and firmly fastened in with wedges, is technically called—is laid upon a table, unlocked, stripped of its side-sticks, footsticks, and furniture, and made naked for dissolution. The various furnitures ought to be put away properly first, and the sidenotes, footnotes, brass rules, or other parts, if any, separated from the main body, and conscientiously put aside. Lifting on his brass setting-rule as many lines (nicks upwards) as he can comfortably hold between his fourth finger and the ball of his thumb, the compositor begins to distribute. The type is held in his left hand, and with the thumb and second finger of his right he lifts a few words from the top line, and lets each letter drop into its proper box. The movement of the finger and thumb separates each successive letter by mere automatic impulse. At first it is a little difficult, but the compositor will find it better to be slow at the beginning than throw the letters into the wrong boxes, and lay up trouble for himself when he comes to set again. With practice, an average man will acquire such speed as to clear away a page very quickly.

Continued

Group 2

EARTHENWARE

1

Following GLASS from page 4949

THE RAW MATERIALS OF POTTERY

Description of the Raw Materials used to Make Plastic Clay. Derivation of the Raw Clays. Preparation of the Mixed Clay or "Body"

By MARK SOLON

THE term *pottery* may be said to apply to all articles made from a plastic substance which hardens under the influence of heat.

These substances occur in Nature in the form of rocks and clays which, when mixed with water, are capable of being moulded into different shapes and have the property of retaining shapes so given to them. When combined with other materials and prepared in a suitable manner they are known as *pottery bodies*.

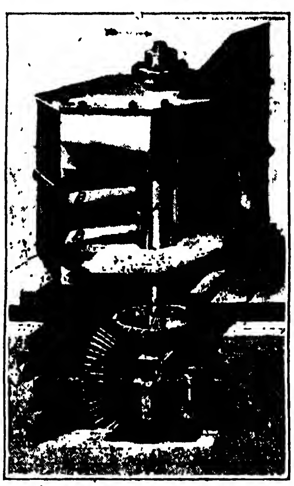
After having been moulded and dried and rendered hard by fire the pieces are said to be in the *biscuit state*, and may then, for domestic and decorative purposes, be coated with a thin film of glass, which, being remelted upon the surface, becomes incorporated with the body, making the piece for all practical purposes impermeable.

The process of pottery manufacture may be briefly treated under the following headings: (1) materials used in plastic bodies; (2) preparation of these materials; (3) manipulation of the clay; (4) drying; (5) firing of biscuit ovens; (6) glazing; (7) decoration.

Materials used in Plastic Bodies. In order to facilitate the study of the properties of the materials from which plastic bodies are made we will take, in the first place, the composition of an opaque body used for the manufacture of ordinary domestic goods and known as "earthenware."

It is necessary for the manipulation, firing, and subsequent glazing of this body, that the materials from which it is made should possess the following properties: plasticity, refractoriness, hardness when fired, and whiteness.

These qualities we find in the natural and artificially prepared clays of Dorset, Devon and Cornwall; in the flint taken from the north coast of France, and in the semi-decomposed granite rock known as Cornish stone.



1. BLUNGING MACHINE

The *plasticity*, upon which depends the ease with which the clay may be worked and moulded, is due almost entirely to the "blue," or "ball," clay of Devon and Dorset, a clay in which the particles are very finely divided and combined naturally with a certain amount of water.

The *refractory* property, which makes the body capable of withstanding the high temperature to which it is submitted during firing, is due to the purer forms of clay artificially prepared, and known as china clay or kaolin, and also to the French flints.

The *hardness* is due to a great extent to the Cornish stone, which fuses during the firing and vitrifies the materials with which it is mixed.

Colour Composition and Derivation. All the above materials are fairly white when fired with the exception of the ball clay. This clay, owing to a small quantity of iron in its composition, develops a slightly cream tint on burning. It is by bringing these materials together in suitable proportions that we are able to make a mixture or body having all the necessary properties.

All clays are hydrated silicates of alumina, or in other words are a chemical combination of silica (the matter of rock crystal), alumina (the matter of sapphire and ruby), and water. They are all derived from felspathic rocks decomposed, naturally or artificially, by the action of water.

China Clay. The rock from which china clay is derived in its natural state consists of silica, about 65 per cent.; alumina, about 20 per cent. to 25 per cent.; potash, 10 per cent. to 15 per cent.

In its semi-decomposed state the silica is visible as quartz or sand, the alumina as fine white clay, while small quantities of under-decomposed felspar and mica are also present.

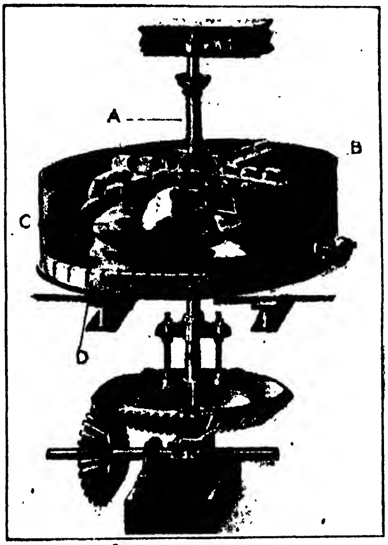
The clay is artificially prepared by running water over the rock into large tanks; the decomposed portion of the rock, being reduced to a fine state of division, is readily removed in mechanical suspension by the water passing over it. During the settling of the liquid in the tanks the quartz and coarse particles of silica fall, while the finely divided particles remain in suspension. The latter constitute the kaolin or china clay, which, after having been dried, have the following composition:

Silica	$46\frac{1}{2}$ per cent
Alumina	38 ,,
Lime and alkalies	2 ,,
Moisture	$9\frac{1}{2}$,,
Combined water	4 ,,
	100

It will be noticed on comparing the analysis of the prepared kaolin with the original rock that the percentage of alumina has increased and the potash entirely disappeared. This is

accounted for by the fact that a large portion of silica remains at the bottom of the settling tanks in an undecomposed state, and the potash becoming soluble on decomposition is washed out.

Ball Clay. Ball clay is a more impure form of clay, being derived either from compound rocks such as Greenstones, which are a mixture of felspar and a mineral named hornblende, or from a pure felspathic rock which, during the course of its natural decomposition by water, has been washed into localities where it has become intermingled with earthy matters in a finely divided state. It generally contains iron pyrites and sometimes lignite carbon and bitumen. It is found in elliptical beds as though deposited by the water into natural basins. As this clay in the course of its decomposition does not undergo any systematic washing we find that a certain quantity (from 1 per cent. to 2 per cent.) of the alkalies remains in the clay. The silica also is always in a higher percentage than in the china clay.



2. GRINDING PAN

Owing also to the length of time that the clay has been decomposing, a greater quantity of it becomes combined with water and the particles become very finely divided, two facts which account for its great plasticity.

The composition of ball clay is as follows:

Silica	50	per cent.
Alumina..	33	,,
Alkalies	3	,,
Iron	2	,,
Water	12	,,
	100	

Cornish stone is merely the semi-decomposed felspathic rock from which the china clay is derived. It varies in fusibility according to the quantity of alkalies it contains.

Preparation of the Body. The approximate proportions in which the foregoing materials should be mixed for the purpose of producing the earthenware body now under consideration are as follows

	Dry weight.	As mixed
Ball clay.. ..	4	12 inches at 24 oz. to pint.
China clay ..	4	8 ,, ,, 26 ,, ,,
Flint	6	6 ,, ,, 32 ,, ,,
Cornish stone	4	4 ,, ,, 32 ,, ,,

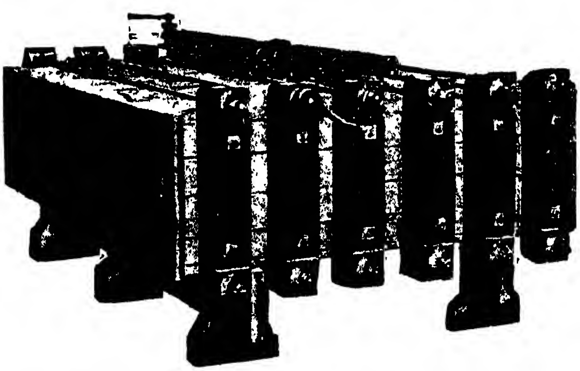
But the exact quantities can only be determined by experiment according to the nature of the actual materials used. Having decided the best proportions, the ingredients are prepared in the following manner:

The first process is to reduce the materials to one standard, in order to ensure accuracy in mixing; to introduce water artificially to assist plasticity; to extract the undesirable impurities which occur in most natural products, and finally to knead the clay and render it homogeneous and of equal consistency throughout. This process is divided into five distinct operations—blunging, lawning, magneting, pressing, and pugging. In the operation called *blunging* the clays are thrown into machines in which they are violently beaten in water until converted into a thick cream or *slip*.

The machines [1], which are octagonal in shape, are fitted internally with a revolving shaft, A, to which are attached a number of blades, B. When put in motion the blades dash the clay in the water against the stationary sides until the former is thoroughly disintegrated.

A certain quantity of the liquid slip, generally one pint, is then brought to a given weight, the ball clay to 24 oz., the china clay to 26 oz., more water or clay being added in the blunger to make the slip lighter or heavier.

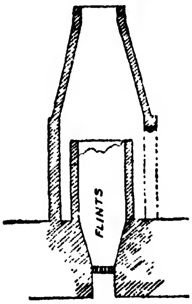
Calcination and Grinding. Having determined the density of the slip in this way the clays are ready to mix with the other ingredients—namely, the French flints and Cornish stone.



3. PRESS OF WOODEN TRAYS FOR CONVERTING SLIP INTO CLAY

These materials are naturally extremely hard and require to be specially treated before they can become part of any plastic body. The flints, which arrive in the form of small boulders or stones, are first of all calcined at a low temperature in specially constructed kilns in order to render them friable and so more readily ground. The kiln [4], which is fitted at the bottom with fire bars, is fed from the top with raw flints mixed with a small proportion of fine slack, the slack on burning producing sufficient heat to calcine

the flints. After calcination they are drawn from the bottom of the kilns, crushed into small pieces, and put upon the grinding pan [2]. The form of pan most generally used consists of a vertical shaft, A, fitted with four arms, B, to which are loosely attached large granite or chert blocks, C. As the shaft is set in motion the granite blocks are carried round in the pan, the under face rubbing against the stone pavement, D. The materials being introduced in the pan with the requisite amount of water, the grinding takes place between the contiguous surfaces of the blocks and the pavement. The large particles which have escaped being properly ground are then separated by running the whole of the liquid into tanks of water, agitating it, and allowing it to settle for a few moments. The particles which remain in suspension are then drawn off ready for use, while those which fall to the bottom are returned to the pan.

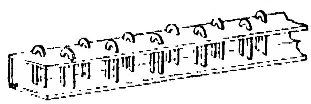


4. CALCINING KILN

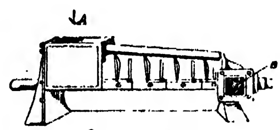
Crushing Cornish Stone. The Cornish stone is ground in the same manner, arriving at the factory in large lumps which simply require to be crushed and put into the pan. Both these materials, after grinding, are treated in the same manner as the ball and china clay, water being added to the bulk until one pint is brought to a given weight, generally 32 oz.

Having obtained all our materials in *slip* of a given density they are run into large mixing tanks, on the sides of which are indicated the number of inches of each material required. At this point an extremely small quantity of cobalt oxide, finely ground, is added to the mixture. This has the effect of counteracting the cream tint which the ball clay develops on firing. The cobalt oxide has the peculiar property of neutralising the staining power of the iron when the latter occurs only in small quantities.

Lawning. The next process, *lawning*, is to abstract all the small impurities, and this is done by causing the slip to fall on shaking sieves, or lawns, which are worked mechanically. From the lawn box the slip is run through a series of magnets, which extract from it the nodules of iron. These are not only present in the natural clay but are liable to get into the slip through the wearing of the machinery.



5. MAGNETS FOR EXTRACTING IRON FROM THE SLIP

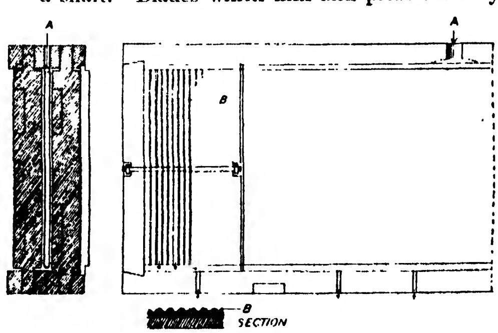


6. PUG MILL

The magnets are arranged in series in long troughs in such a way that they can be easily taken out and the iron adhering to them washed off [5]. It is extremely important that no metallic iron should be allowed to remain in the clay, for this, when fired, will appear in the form of small brown specks.

Draining off Superfluous Water. Having mixed our materials thoroughly in the slip state we must now get rid of the superfluous water and convert the slip into clay. To accomplish this filter presses [3] are employed, machines in which the liquid slip is compressed by means of a force pump into coarse cotton bags, which retain the clay, allowing only the water to escape. The type of press generally used consists of a series of about 24 wooden trays [3] bound together by means of iron rods. Between each tray occurs a space, which is lined with strong cotton sheets. By folding the edges of these sheets a bag is formed. The slip under pressure enters at the point A [7] through small brass tubes. The water, flowing down the channels in the tray, B, escapes through small holes at the bottom. After the bags are filled with clay the iron rods which bind the trays together are undone, the trays separated one by one, and the flat cakes of clay taken from between the cotton sheets.

Pugging. Although the clay now contains only the right amount of water, it is not homogeneous, and requires to be put through a mixer or *pug mill* [6], in which it is thoroughly kneaded and delivered at one equal consistency. The machine consists of an iron cylindrical tube, open at both ends, through the centre of which runs a shaft. Blades which mix and press the clay,



7. DIAGRAM OF PRESS FOR CONVERTING SLIP INTO CLAY

expelling the air from it, are attached to the shaft at a slight angle. The clay is fed into the machine at the mouth A and delivered in a solid block at the point B.

Continued

POLYGONAL & CURVED ARTICLES

Octagonal Vase. Ogee Moulding. Elliptical Pans, and Pans with Slanting Sides. Articles with Unequal Slant

TECHNICAL DRAWING
continued from page 5062

By JOSEPH G. HORNER

THE problems involved in the practice of sheet-metal working are so extremely numerous that nothing more than elementary principles can be taken for illustration here. In previous articles we have dealt with the principal geometrical forms. In this and the one to follow we shall show some applications of the same.

Some Polygonal Forms. The method of stepping round circular arcs has been shown in several problems. We now illustrate that method applied to figures which are curved in one direction only, but combinations of which figures in the other direction give various polygonal forms of great beauty. Among the applications of such designs are vases for ferneries and conservatories, the bases of ornamental columns, and such objects as aquaria and fern cases, tureens and other vessels. No great technical skill is required in their design, and when the principles of one or two forms are understood, any others may be drawn. Two examples are given, the first that of an equal-sided figure [**113**], the second [**116**] having sides of unequal lengths.

Pattern for an Octagonal Vase. Fig. **113** is the profile of an octagonal vase in half elevation. Taking the largest diameter; from the centre line *o o* to the point 1 near the top, draw an outline of the plan as in **114**, one-quarter of the view being sufficient. Make the horizontal line 1 0′ [**114**] the centre line of one of the flats of the octagon, and let the diagonal line 1′0′ below it represent the angle from the centre 0′ to the termination of the same flat. This is obtained by first drawing a quadrant of a circle and dividing it into four, but the two lines 1 0′, 1′0′ are the essentials that are afterwards required. Now divide the profile [**113**] into any convenient number of parts, stepping round the outline with dividers, and afterwards dividing the perpendicular centre line *o o* [**115**] similarly. The divisions are numbered 1, 2, 3, etc., alike on **113** and **115**. From **113** project lines from all these points down to **114**, passing through the horizontal line 1 0′, and cutting the radial line 1′ 0′ below at 1′, 2′, 3′, etc., these intersections being similarly numbered to correspond with the points in **113** from which they are projected.

The dividers are now set in turn to each of the vertical distances in **114** on the lines 1 1′, 2 2′, etc., measuring from the horizontal 1 0′ to the diagonal 1′ 0′. These lengths are transferred to each side of the perpendicular centre line *o o* [**115**] on the horizontals similarly numbered; the distance 1 1′, for instance, in **114** corresponding with 1 1 on each side of the centre *o o* in **115**. Through the points thus obtained in **115** the outline of one face of the octagon can be traced. To avoid confusion of lines the projection and numbering are not shown farther than 10 at the upper part of the vase, but the lower part is marked out similarly.

Rectangular Base with Ogee Moulding of Equal Curves on all Sides. Fig. **116** is a side elevation showing the profile of an ogee moulding, and **117** is a half view of its plan. A half plan of the developed pattern is shown in **118**. To construct **118**, transfer the rectangle 2 2 2 2 from **117**, and add to its side and ends the depth 2 3 from **116**, similarly numbered in **118**. Then divide the curved portion in the profile in **116** into any number of equal parts by stepping round the curves with dividers, and draw horizontal lines from one end to the other through these points, as at 4, 5, 6, 7, 8. With the dividers still set to these divisions, step off on **118** the same number of divisions on the perpendicular centre line 1 1, beginning at the horizontal line 3 and ending at 9; and, similarly, also from 3 to 9 at each end on the transverse centre line 10 10. Draw lines from all these points as shown dotted in **118**, at right angles to the lines they are stepped off on. Add the depth 9 10 from **116**, giving the horizontal line 10 10 at the base of **118**, and the outer perpendicular lines 10 10 at each end. Take the length of the base 10 to 10 from **116** or **117**, and transfer it to the base 10 10 in **118**. Take the width of the base from **117** and transfer it to the end perpendiculars 10 10 of **118**. Working from the centre line 1 1 of **116** and **118**, take in turn all the distances 1 to 4, 1 to 5, etc., from **116**, and transfer them to the horizontal lines similarly numbered in **118**. These will give the points 3, 4, 5, 6, 7, 8 at each end of the dotted horizontal lines in **118**. To obtain the lengths of the corresponding perpendicular lines on the ends, take the distance 10 to 12 from **117** and mark off a corresponding distance on the base line of **116** from 10 to 12. The point 12 thus obtained marks the position of the vertical dotted line 11 12, which, in relation to the end it is measured from, is equivalent to the centre line of an end elevation. The measurements are taken from this line 11 12 [**116**] to the points 4, 5, etc., on the side from which the distance 10 12 has been measured, and are transferred to the correspondingly numbered perpendicular lines at each end of **118**, and the curves drawn through the points thus obtained.

We now take some concrete examples in which problems that were treated under conic frusta are embodied. Two general cases occur—that of objects having equal slant or flue all round, and that of others in which the slant is not equal. These problems may be treated

directly as completed cones, or by the methods of triangulation in which the apex is inaccessible. Figs. **119** to **129** deal with objects of equal slant.

Development of a Tapering Elliptical Article in One Piece. Draw the elevation and plan of the article as in **119** and **120** respectively. Draw the perpendicular line 3 2 [**121**], and at right angles to it the lines 3 10, 5 11, at distances apart which indicate the depth of the article, 3 to 5 [**119**]. From **120** take the radii of the end curves of the ellipse, 1 9 and 1 8, and transfer them to the horizontal lines in **121**, thus obtaining the points 8 measured from 3, and 9 measured from 5. Through the points 8 and 9 draw the diagonal line terminating at 1, where it cuts the perpendicular 3 2. Take the radii of the sides of the ellipse, 2 10 and 2 11, from **120**, and transfer them similarly to the lines 3 10 and 5 11 respectively in **121**, thus obtaining the points 10 and 11, through which the diagonal 10 2 is drawn. Now draw the perpendicular 8 1 [**122**], and with the distance 1 8 from the first diagonal in **121** taken as a radius, describe the curve from 14 to 15 from the centre 1 [**122**]. The length of the curve must correspond with the length 14 15 on the plan **120**, and the measurement is transferred by stepping it off with dividers, as already explained in connection with other problems. From the points 14 15 [**122**] project lines through the centre 1, and to some distance beyond, on which to obtain the points 2 2. These points are then set off by taking the distance 2 10 from the second diagonal in **121**, and marking them from 14 to 2 and 15 to 2 on **122**. With the points 2 2 as centres, the curves 18 14 and 15 16 are continued from the ends of the first arc, their lengths being taken from the curve 15 to 16 on **120**. The radius 1 8 is then taken from the perpendicular line in **122**, and set off from the points 18 and 16 to give the points 19 and 20 on the lines 18 2 and 16 2. The points 19 and 20 are the centres from which the curves are continued from 18 to 21 and 16 to 17, their length being taken, as before, from the plan [**120**] or from 14 or 15 to 8 [**122**]. Radial lines are then marked from 21 to 19, and 17 to 20. The inner curves, 9 11, are struck from the same centres as the outer, the radii being obtained from **121**. The radius of the smaller curve is 1 to 9 on **121** and **122**, and the radius of the larger curve 2 to 11 similarly on both.

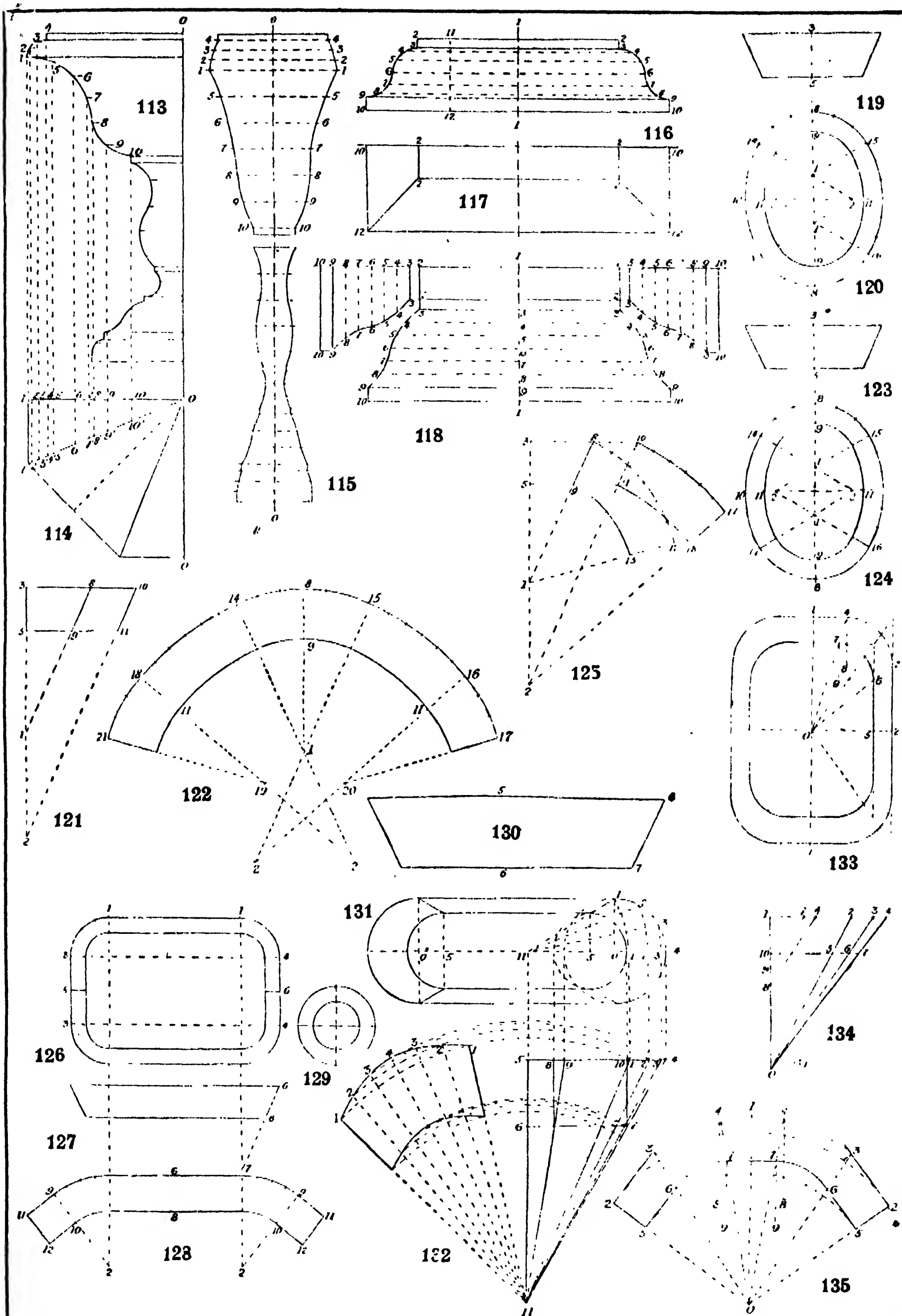
Shape of the Parts of a Tapering Elliptical Article made in Four Pieces. This is a variation on the previous problem. Fig. **123** shows the article in end elevation, and **124** in plan, figured similarly to the preceding ellipse [**119, 120**]. In **124**, 1 1 and 2 2 are the centres from which the curves of the ellipse are struck. Draw a vertical line, 3 2 [**125**], and two horizontal lines from it, 3 10 and 5 11, at a distance apart corresponding with the vertical depth, 3 5, of the article. Take the radius 1 8 [**124**] with which the larger end curves are struck and transfer it to **125** on the line 3 to 8. Take the smaller radius 1 9 from **124**, and transfer it to 5 9 on **125**. Draw a line through the points, 8 9, thus obtained, continuing it on to 1, where it intersects the perpendicular line 3 2. With 1 for a centre and 1 8 as radius strike the curve 8 12, and, similarly, the inner curve 9 13 from 1, with 1 9 as radius. The length of the segment is obtained by measurement from **124**, a number of points being stepped off round the curve from 14 to 15 [**124**] and the same number transferred to the curve 8 12 [**125**], and a line is then drawn from 12 to 1, completing the segment. The segment 9 8 12 13 thus obtained gives the shape of the end pieces minus laps for jointing.

To obtain the shape of the side pieces, take the radius 2 10 from **124** and set it off from 3 to 10 on **125**, and the inner radius 2 11 [**124**] set off from 5 to 11 [**125**], projecting a line through these points to the point 2 on the line 3 2 in **125**. The point 2 is the centre, and the distances 2 10 and 2 11 are the radii with which a segment for the sides is struck, its length being obtained by stepping round in **124** along the curve from 15 to 16 and transferring to the curve 10 17 in **125**, the outer end being marked radially from 17.

Shape of a Tapering Pan in Two Pieces. Fig. **126** is a plan, and **127** a side elevation showing the depth of a tapering pan. To obtain the shape of one half [**128**], draw the vertical lines 1 2, 1 2, through the centres from which the corner radii in **126** are struck. Draw at right angles to them, also through the centres, the lines 3 4, 3 4. Draw also a central horizontal line 5 6, which will indicate the joint between the two parts. Continue the slant of the end [**127**] from 6 down to 7, where it cuts the perpendicular line 1 2. Draw the horizontal line 6 [**128**], stopping it at the perpendiculars 1 2. Take the length of the slant edge from 6 to 8 [**127**], and mark it off from 6 to 8 on **128**, and draw the second horizontal line, 8, through it. With 7 6 [**127**] as radius describe the arcs which are continued from the horizontal line 6 in **128**, the centres from which they are struck being on the perpendicular lines at 2. Describe also the inner arcs from the same centre, with the radius corresponding with 7 8 on **127**. Measure the length of one of the outer curves on **126**, as indicated by the divisions at the corner 1 3, and step round the outer curves on **128** to the same length. From the points 9 9 thus obtained draw lines to the centres 2 2. From 9 and from 10 it is now necessary to carry lines at right angles with the lines 9 10, corresponding in length with 3 5 and 4 6 in **126**. This gives the points 11 and 12 in **128**, and it only remains to connect these by the lines 11 12.

Although the figures given are those of complete objects, it often happens, especially in platers' work, that some particular section only is required, such as one curved end or one curved corner. But it is frequently helpful then to mentally regard the fragmentary portion required as part of a complete figure, by which its relations are mentally rendered more obvious. In **125**, for example, sectional portions only may be required.

Fig. **129** shows a method of marking out which does not necessitate drawing a complete plan of



PATTERNS FOR POLYGONAL AND CURVED ARTICLES

113, 114. Vase in sheet metal **115.** Development of one side of vase **116, 117.** Base with ogee moulding in sheet metal **118.** Development of base **119, 120.** Elliptical tray with equal slant **121, 122.** Method of development of tray **123, 124.** An elliptical tray **125.** Development of tray made in four pieces **126, 127.** A tapering pan with rounded corners **128.** Half pattern for pan **129.** Plan of rounding corners only **130, 131.** A bath having its ends sloping more than its sides **132.** Development of one end of bath **133.** Tray with rounding corners with unequal slope **134, 135.** Development of pattern of tray

the tray as in 126. Two complete circles are drawn on the same radii as the outer and inner curves at the corners of the tray, the intervening straight parts being omitted. The length of the straight parts being known, they are inserted in the construction of 128 without transferring them from a plan view. Similarly, it is not necessary to draw the complete elevation, as in 127, but only the triangular portion comprising the points 6, 8, 7 [127], and the perpendicular and horizontal lines connecting them.

Figs. 130 to 135 deal with objects having unequal slant. Such objects are very frequent. In approaching problems of this kind some of the methods described in earlier articles have application. In all such cases a development is necessary, in order to obtain the actual radius of the developed sheet, by ascertaining first the relations between the vertical and the slant heights of the curved portions, obtained in the form of a right-angled triangle.

Round-end Bath Sloping more at the Ends than Sides. Fig. 130 is the elevation, and 131 the plan of the round-end bath. The outer semicircles in the plan are struck from the points *o*, and the inner ones from 5. Complete the two circles as shown dotted at the right-hand end [131], and divide one quarter of the outer circle into an equal number of parts, as 1, 2, 3, 4. Draw in 132 the horizontal lines 5 4 and 6 7, at the same distance apart as the lines similarly numbered in 130, and representing the vertical depth of the article. Project the diameters of the circles down from 131 to 132, intersecting the horizontal 5 4 at the points 8, 9, 10, 4; and from 8 and 10 continue them to the lower line 6 7. Draw lines through 4 and 7 and from 9, projecting them till they meet at the centre 11. From 11 [132], draw a vertical line to 11 on the centre line of 131. From the centre 11 [131] describe arcs from the points 1, 2, 3 on the circle to cut the centre line 11 4 at 1, 2, 3. From these points draw perpendiculars to the line 5 4 in 132, and then continue them from these points to meet at the centre 11. Draw also radial lines in 131 from the points 1, 2, 3, on the circle, to meet at the point 11 on the centre line. These cut the smaller circle and divide it similarly to the larger one. With the point 11 in 132 as a centre, strike curves from the intersections 1, 2, 3, 4 on the line 5 4, continuing them round to the left indefinitely, as shown. Also, from the same centre, strike the inner set of curves from the points 7, etc., of the intersections of 1, 2, 3 on the line 6 7. The radial centre line of the pattern may now be drawn from 11 to the outermost circle to the left of 132, cutting it at 4, which is placed at a sufficient distance away from the perpendicular to allow the pattern to be marked out without confusion of lines. The divisions 1, 2, 3, 4 are taken from the circle on 131 and transferred to each side of 4 [132], stepping from one curve to the next adjacent, so that the circumferential division 3 comes on the arc 3, and the circumferential division 2 on the arc 2, and so on. The pattern outline is then traced through these points of intersection, and at the ends 1, 1, radial lines are drawn to the centre 11. The inner edge of the pattern may be obtained by similarly dividing from the smaller circle in 131, but a simpler method is to draw radial lines from each of the outer points to the centre 11, as shown in 132 (left hand), and trace through the intersections of the radial lines with the inner set of curves.

Rectangular Tray with Rounding Corners. This example has greater slant at the ends than at the sides. The outer dimensions in the plan [133] being decided on, draw radial lines from the corners of the completed rectangle to the centre *o*. Determine the width or length of the inner rectangle, which forms the base, and draw that with corners meeting at the radial lines. From the centre 8, from which the outer sweep is struck, project horizontal and perpendicular lines to 3 and 4, and from 3 and 4 draw radial lines to the centre *o*. From 6 and 7, where the lines *o*3 *o*4 intersect the inner rectangle, project horizontal and perpendicular lines to the point 9, which is the centre from which the inner sweep is struck. Then [134] draw the two horizontal lines 1 4 and 10 7, corresponding in their distance apart to the vertical depth of the tray, and draw the perpendicular 1*o*. Then, from 133 take the lengths *o*4, *o*3, and *o*2, and transfer them to 1 4, 1 3, and 1 2 respectively on the top line of 134. Take also from 133 the lengths *o*7, *o*6, and *o*5, and transfer them to the line 10 7 in 134. Draw lines in 134 through 4 and 7, 3 and 6, 2 and 5 to intersect the perpendicular at *o*. Then, from 133 take the radii 8 to 4 and 9 to 7 and transfer them to the top line of 134 from 1 to 4, and 1 to 7 respectively, and draw lines from the points 7 and 4 parallel with the line 3 6 *o*, so that they cut the perpendicular at 8 and 9.

Next draw the vertical centre line 1*o* of 135, and with the radius *o*4, taken from 134, describe the arc 4 4. The distance of the points 4 from each side of the centre line 1*o* corresponds with the distance 1 to 4 on the plan line at the top of 133. A horizontal line is now drawn between 4 4 on 135, also a radial line from each end, 4 4, to the centre *o* [135]. Next take the radii *o*3, *o*2 from 134, and from the centre *o* [135] describe the arcs 3 3 and 2 2. Take also from 134 the radii *o*7 and *o*5 and describe the arcs of corresponding numbers on 135. Draw perpendiculars from 4 4 and 7 7, and with the radii 8 4 and 9 7 from 134 set off the points 8 and 9 respectively on the perpendiculars 8 4 and 9 7. From centres 8, 8, describe the outer curves from 4 to 3, the point 3 being that where they cut the large curve 3 3. From the intersections at 3 draw radial lines to the centres 8, 8, and also to the centre *o*; connect 7 7 by a chord similarly to 4 4, and from centres 9, 9 describe the curves 7 6, terminating at the radial lines 3*o*. From the points 3 and 6 draw lines tangential to the curves at 2 and 5, and radial lines from those points to the centre *o*. This completes the pattern for one half of the tray, to which allowance must be made for jointing.

Continued

WIRE AND WIRE WORK

Wire Rods and Wire-drawing. Making Pins and Needles. Coiling and Weaving Wire. Wire Ropes and their Manufacture. Wire Netting

Continued from page 5010

THE manufacture and working of wire embrace a group of industries the processes in which are seldom described in popular books. This neglect of the wire trades is rather surprising in view of the importance of these trades. The wire-making industry is one of the foundations of our civilisation, and the low cost to which mechanic skill has succeeded in bringing articles of wire enables such articles to be the property of the many. The ordinary pin is turned out at the surprisingly low price of something like one penny per thousand, and each pin has to undergo many operations. The domestic sewing needle is as fine an example of the result of highly developed manufacturing skill as any trade has to offer, and its low price is a surprise to those unfamiliar with its manufacture. Carding wire is an essential in the textile trades, coal and other minerals are raised from the mines by wire ropes, without which the cost of mining would be greatly increased, wire fish-hooks are a necessity to the fishing industry, the modern watch would be impossible without springs of flattened steel wire, wire torpedo nets guard our battleships from hostile attack, and finally wire guns are the weapons of offence used in our Navy and coast defence stations. These few instances of the uses of wire may serve to illustrate its importance to the community, and we may proceed to describe its manufacture and employment.

Iron and Steel Wire. The processes through which the material has to pass before finally emerging as wire demand that good iron and steel should be used for the purpose. Puddled iron and charcoal iron [see page 4635] are used. High qualities of wire, including music wire, are made from Swedish iron, which is a special quality of charcoal iron. Steel used in wire manufacture must be free from both phosphorus and sulphur, or the result will be very poor wire. Only steel can be employed in making articles which are to be tempered. From Mr. Bucknall Smith's "Wire: Its Manufacture and Uses" we extract a table showing the average breaking strains of wires made from different classes of iron and steel.

	Tons per sq. in. of Section.
Black or annealed iron wire	25
Bright hard-drawn iron wire	35
Bessemer steel wire	40
Mild Siemens-Martin steel wire	60
High carbon Siemens-Martin steel wire (or "improved")	60
Crucible cast steel improved wire ..	100
"Improved" cast steel "plough" ..	100
Special qualities of tempered and improved cast steel wire may attain ..	150-170

The drawers of wire purchase their material either in the form of billets or of wire rods. In either case they specify quality according to the purpose to which the wire has to be put. If they purchase in billets they must roll them into rods. A "billet" is an ingot of iron or steel usually of somewhat irregular shape in section, but approximating to square and weighing between 80 lb. and 200 lb. These billets are passed, when hot, through rolling mills and emerge as "wire rods." These rods are really coils of wire from 200 ft. to 600 ft. long, the length differing with the size of the original billet and with the diameter to which rolling has reduced it.

Rolling Wire Rods. Productive economy makes it desirable that the rods should be rolled in one heat, as the necessity of reheating when the rolling is partly accomplished adds to the cost materially. Rolling is performed in a series of machines usually called a "train." We may describe them as a number of large mangles with iron rollers provided with grooves around their peripheries. There are two rollers in each machine and both rollers are grooved alike. Some mills have three rollers, but for the sake of lucidity we may discard this consideration. The grooves are not all semicircular in shape. They may be diamond shaped or oval as well. The shape is varied, because the practice "works" the material into a uniform mass, increasing both its tenacity and ductility. The pairs of rollers have grooves which in size are in a descending scale. The red-hot billet passes through the largest grooves—say round—then through rollers with grooves a little smaller—say of diamond shape—then through others still smaller with oval grooves, and so on through the entire series, the shape of the section varying and the size of the section decreasing throughout the cycle. Then, after perhaps ten or twelve different "passes" through rolls, the rod is of the desired diameter, and as it leaves the last pair of rollers it is wound, still hot, on drums which make it into coils. Such in bare outline is the history of the "billet" during its transformation into the coil of thick wire known as a "wire rod." Various followers of the process have introduced modifications, chiefly in the direction of automatic mechanisms for handling the rod as it passes from one pair of rollers to another, but the essential principle in all is as we have described it. The rollers, of course, are "live rollers"—that is to say, they are driven by power from an engine, so that they pull through the rod under treatment. Also the rollers have a speed of revolution that increases as their grooves decrease in size. This higher speed is to compensate for the greater length of the rod as it is drawn out by rollers with smaller and smaller grooves. Some rolling mills are arranged so that several rods can be made to pass through at one time, several pairs of grooves being provided on each pair of rollers. This is the highest point in productive economy. After rolling, the rods are cleaned in a tank containing a diluted solution of muriatic or sulphuric acid, are put into lime-water and are finally dried in an oven. They are then ready for the drawing mill.

Cold Drawing. The rolling is over and has given us the wire "rods" or coils usually of No. 5 or No. 6 gauge, the former just over and the latter just under one-fifth of an inch in diameter. The

lengths of the rods are from 200 yards to 600 yards long, according to the weight of the billet from which they have been made. The rods were made hot; they are drawn into wire cold. The wire may be one of many shapes—oval, flat, round, square, or U-shaped, according to the shape of the dies through which it is passed. The draw-plate is merely a piece of hard steel with holes of different sizes through which the wire is drawn successively, each hole through which it is taken being smaller than the preceding one. The number of holes through which the wire is drawn depends upon the reduction in diameter required. The finer the wire is to be, the greater is the reduction and the more numerous the passes through the draw-plate. The plates are given to wear, the strain to which they are subject in use being very great, and when the holes have become enlarged by use the plates are heated, hammered, and the holes repunched and made accurate. The end of the thick wire or "rod" is hammered to a point, making an inch or two at the extremity thinner than the body, and able to be put through one of the holes in the draw-plate.

The Drawing Mill. The wire-drawing mill [1] is a bench mounted with a series of "blocks" or pulleys from 12 in. to 30 in. diameter, turning on vertical centres and with a draw plate and pincers to each pulley. The end of the rod, where it has been made thinner in the manner stated, is put through the selected hole in the draw-plate, and placed in the jaws of the pincers, which are attached to a bar. A cam attached to the drum spindle is made to operate, and it pulls or presses the bar and pincers away from the draw-plate, thereby drawing a little of the wire, enough to make a revolution of the drum to which it is made fast. Then the drum itself is put in motion, and the wire is drawn through the die or draw-plate as rapidly as the drum is made to revolve. The speed which can be maintained in working depends upon the amount of attenuation being given and upon the material.

Lubricant. The work of drawing is made more easy by the use of a lubricant. For thick gauges the lubricant is usually of paste consistency—a heavy grease; but for gauges below 20 a thin lubricant such as soapy water is employed. The lubricant not only facilitates the actual work of drawing through the plates, but it also, if wisely chosen, leaves a thin film of grease, which prevents oxidation.

Manufacturers use various lubricants in wire drawing, and each manufacturer is a law to himself in the matter. For fine drawing, a lubricant made of sour beer yeast and olive oil is sometimes used. It is claimed for a mixture of lard and sulphuric acid thinned with water that its use saves a good deal

1. WIRE-DRAWING BENCH
Thomas Barraclough, London)

of the annealing otherwise necessary in the various stages of drawing. A hot solution of lime and salt is used by some makers when drawing steel wire. This practice is said to save wear upon the inner surface of the die.

Annealing. With the repeated drawing the wire becomes hard, and it is necessary, perhaps several times during the sequence of the drawing operations, to anneal the coils. Wire reduced to a fine gauge may have been annealed about six times during its progress from the wire rod. Some makers, before annealing iron and steel wire, immerse it in a thick cream made with chloride of lime and water. This gives it a protecting coat, which prevents the formation of scale during annealing, and which is afterwards removed by washing in clean water. The annealing ovens are air-tight iron chambers capable of holding from two to three tons of wire coils. They are charged and closed. Then they are heated up to 600° F. or 700° F. The duration of the heat depends upon the gauge of the work in hand and upon the quantity in the chamber. When it is considered that the heat has been maintained long enough, the furnace is allowed to cool slowly. When cool, the wire is withdrawn and "pickled" in acid solution as after rolling, and before the work of drawing proceeds again, another immersion in limewater is given. Then the work goes ahead as before, to return to the annealing chamber should it be necessary. Finally, we have the wire drawn to its final shape, and it is ready for the market or for one of the many industries in which wire is used.

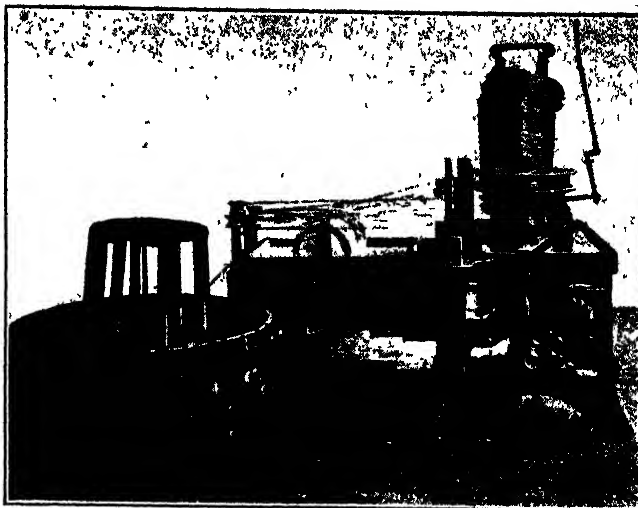
Continuous Drawing. Continuous wire-drawing [2] has come into extensive use during recent years, and is economical. In machines for continuous drawing the wire is not wound on a block, as in ordinary wire-drawing, already described, but is pulled through one die, wound two or three times round a block, then passing through another die, round another block, and so on until the ultimate desired gauge is attained. The circumferential speeds are varied to compensate for the elongation of the wire as it passes through the dies. Metals that require frequent annealing during the process of drawing are limited in the number of dies through which they can pass at one time. Thus, in drawing iron, steel, and brass wire, the saving in working with continuous machines is much less than it is with a metal like copper, which can usually be drawn to its ultimate gauge without annealing.

Our illustration [2] shows the wire reel, which is being drawn down through the several dies, mounted in a tub containing weak acid. This practice is frequently followed, and removes any acid that may have been given to the surface of the wire during the process of annealing. The drawing drums may vary in diameter from 10 in. to 32 in. and may revolve at a circumferential speed of from 300 ft. to 400 ft. per minute. Steel wire, however, must be drawn at a slower speed, to obviate risk of breakage. Soft iron wire and copper wire may be drawn at the rate of 500 ft. per minute, or even more.

Fine Drawing. When, for special purposes, such as watch-springs, fineness and absolute accuracy are demanded, the steel draw-plate is discarded and precious stones, drilled to the required size, are used for the final drawing. The ruby is the usual stone employed, although diamonds and sapphires are also used. A silver wire 170 miles long and ·003 in. diameter has been drawn through a hole in a ruby, and upon micrometer measurement it was found that the size towards the end of the

coil was exactly the same as at the beginning. A hole in a steel plate would have shown signs of appreciable wear with one-tenth of the work. When the ruby or other gem is used, it is mounted in a metal plate, and for flat work, such as the hair-spring of a watch, the hole must be of rectangular aperture.

Wire Gauges. The question of wire gauges is a vexed question, into the details of which we do not intend to enter. For very many years there was no uniformity in the wire gauges, and this led to much confusion and to many mistakes. Every maker almost was a law unto himself, and during the greater part of last century there were over forty different wire gauges used in this country alone. This state of matters was remedied in 1884, when the Board of Trade, after deputations, from wire manufacturers and consultations with them, inaugurated and made the legal standard of wire measurement in this country the "Imperial Standard Wire Gauge," which is usually designated by the letters, "S.W.G." Yet some of the discarded gauges still linger in practice, notably the "Birmingham Wire Gauge." We append a table giving the Imperial wire gauge, the Birmingham wire gauge, and the equivalent sizes in decimals of an inch, and in millimetres. The French and German practice is to reckon wire by millimetre sizes.



2. CONTINUOUS WIRE-DRAWING MACHINE
(Bond & Cooper, Birmingham)

IMPERIAL STANDARD AND BIRMINGHAM WIRE GAUGES

Imperial Wire-gauge	Birmingham Wire-gauge	Equivalent Diam. Inches	Equivalent Diam. Millimetres	Imperial Wire-gauge	Birmingham Wire-gauge	Equivalent Diam. Inches	Equivalent Diam. Millimetres
7/0	—	·500	12 699	14	—	·080	2 032
6/0	—	·464	11·785	15	15	·072	1 828
—	0000	·454	11·531	—	16	·065	1·650
5/0	—	·432	10·972	16	—	064	1·625
—	000	·425	10·794	—	17	·058	1·472
0000	—	·400	10·159	17	—	·056	1·421
—	00	·380	9·651	—	18	·049	1·244
000	—	·372	0·448	18	—	·048	1·218
00	—	·348	8·839	—	19	·042	1 066
—	0	·340	8·635	19	—	·040	1·016
0	—	·324	8·229	20	—	·036	·9140
1	1	·300	7·620	—	20	·035	·8886
—	2	·284	7·213	21	21	·032	·8124
2	—	·276	7·010	—	22	·030	·7617
—	3	·259	6·578	22	—	·028	·7109
3	—	·252	6·400	—	23	·025	·6347
—	4	·238	6·645	23	—	·024	·6093
4	—	·232	5·892	24	24	·022	·5585
—	5	·220	5·588	25	25	·020	·5078
5	—	·212	5·384	26	26	·018	·4570
—	6	·203	5·156	27	27	·016	·4062
6	—	·192	4·876	28	28	·014	·3555
—	7	·180	4·571	29	29	·013	·3300
7	—	·176	4·470	30	30	·012	·3046
—	8	·165	4 191	31	—	·011	·2800
8	—	·160	4·064	32	—	·0108	·2743
—	9	·148	3·759	33	31	·010	·2539
9	—	·144	3·657	34	32	·009	·2300
—	10	·134	3·403	35	33	·008	·2031
10	—	·128	3·251	36	34	·007	·1777
—	11	·120	3·047	37	—	·0068	·1727
11	—	·116	2·946	38	—	·006	·1523
—	12	·109	2·768	39	35	·005	·1269
12	—	·104	2·641	40	—	0048	·1219
—	13	·095	2·412	41	—	·0044	·1118
13	—	·092	2·336	42	36	·004	·1015
—	14	·083	2·108				

Drawing Properties of Various Metals. The drawing qualities of metals are due to their ductility and tenacity. Ductility is the capacity of changing molecular form, and ten city is the power of resisting separation. When these qualities are high and are combined in a metal, that metal possesses excellent drawing properties. Most metals are capable of being drawn into wire, although some—as, for instance, antimony—are brittle and useless for want of tenacity. Gold is the most ductile of the ordinary metals, and it is followed by silver, platinum, iron, copper, zinc, tin, and lead in the order named. Steel, again, is the most tenacious of the metals, and is followed by iron, copper, platinum, silver, gold, zinc, tin, and lead in the respective order.

Metals are sometimes drawn in combination. Steel wire of large gauge, after cleaning in a solution of sulphuric or muriatic acid, may be given a coating of copper by immersion in a solution of sulphate of copper. If the copper-coated wire be then put through the draw-plate, it may be drawn very fine, the copper remaining unbroken, but attenuated. Silver-gilt wire is made in the same way. The coating of gold upon a silver bar or rod may be less than one-thousandth part of the latter, but drawing this out to hair thickness still leaves an unbroken coating of gold upon the cheaper metal.

Telegraph Wire. Both iron and steel wire are used for telegraph purposes. For lengthy spans, and where great tensile strength is necessary, steel wire is preferred, but wire made from Swedish charcoal iron is used for ordinary work. The wire is generally galvanised [see Galvanising.] The qualities demanded in wire for telegraph purposes are ductility in a high degree and freedom from flaws and impurities. Phosphorus and manganese impair electrical conductivity, hence wire for telegraph purposes should be free from these impurities. It is considered, however, that carbon and silicon have no influence upon electrical conductivity. Government departments and railway companies have rigid specifications stipulating the size, weight, electrical resistance, the minimum number of twists in the strand, and specific tests for strength

and ductility of wire to be used for telegraph purposes.

For covered telegraph and telephone work, a wire of silicon bronze is much used. This alloy is found to be very high in electrical conductivity. Here are two analyses of such wire:

Telephone Wire.		Telegraph Wire.	
Copper ..	99·94 per cent.	Copper	97·12 per cent.
Tin	·03 ,,	Tin ..	1·14 ,,
Silicon ..	·02 ,,	Silicon	·05 ,,
Iron ..	trace	Zinc ..	1·62 ,,
		Iron ..	trace

Fencing Wire. Both plain and strand wire are largely used for fencing, the latter having preference in this country. Where large tracts have to be enclosed and cheapness is a consideration, cheap iron or steel wire (usually No. 8 S.W.G.) black varnished is used. A coil contains between 500 and 600 yards, and weigh cwt. Fencing of strand wire is usually galvanised.

Barb Wire. Barb wire for fencing owes its origin to America. It might with justice be called "barbarous" wire. It no doubt fills a practical purpose in times of both peace and war, and the quantity manufactured is very great. It is usually galvanised after having been made.

Two wires, generally of 12 or 14 standard wire gauge, are twisted together, and the barbs (short pieces cut obliquely at both ends and wrapped twice round the main strand with their ends projecting) may be "open-set"—that is, be about 6 in. apart, or "thick-set"—that is, be from 3 in. to 4 in. apart. It may be "two-point," or "four-point," which mean that the barbs may be single, presenting two points only, or they may be set double when there are four points of danger for the unwary every few inches. Barb wire contains from 335 lb. to 440 lb. to the mile.

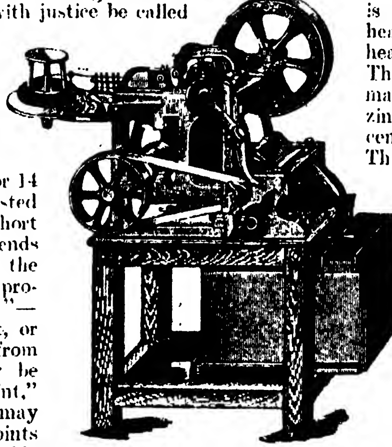
There are a few other varieties of barb wire; in one, a strip of serrated hoop iron is enclosed in the strand, and in another a plain single-strand wire of oval section has its edges cut obliquely, the spikes made thereby being raised so as to offer offence to the intruder; but the pattern to which we have already made reference is made in overwhelming proportion.

Piano Wire. The piano manufacturing trade is a large consumer of steel wire. The great and constant strain to which steel wire is subject when strung in a piano demands a quality of wire capable of resisting this tensile strain without breaking and without elongation. The total tension upon the wires of a grand piano approaches 20 tons. The strain upon one wire in a piano is as great as if the writer, or the reader—unless he be abnormally heavy—were suspended from it. The carbon in steel used for piano wire ranges, according to Mr. Bucknall Smith in special tests made by him upon samples from various makers, from ·570 per cent. to ·740 per cent.; silicon from ·032 per cent. to ·205 per cent.; sulphur up to ·017 per cent.; phosphorus from ·004 per cent. to ·018 per cent., and manganese from ·120 per cent. to ·425 per cent. Physical properties of the wires tested were as follows in three samples upon which experiments were made.

Diameters.	·040 in.	·036 in.	0·37 in.
Torsion or turns in 6 in...	60 to 70	30 to 40	60 to 70
Ultimate tensile strength	400 lb.	318 lb.	340 lb.
Equivalent tension per inch of section	142 tons	140 tons	141 tons

The music wire gauge differs from the "Imperial standard" (S.W.G.) wire gauge. It is as follows:

Music Wire Gauge.	12	13	14	15	16	17	18	19	20	21	22
Diameters in inches	·029	·031	·033	·035	·037	·039	·041	·043	·045	·047	·052
Nearest size in Imperial Wire Gauge	22	21	21	20	20	19	19	19	18	18	17



3. PIN-MAKING MACHINE
(Kirby, Beard & Co., Ltd., Birmingham)

Steel piano wire must be hardened, and this is usually done before the wire goes through the last drawing operation. The procedure is as follows: The wire is first heated in the ordinary way to red heat, and then allowed to cool. Then it is placed in a metal bath made of 40 per cent. lead, 12 per cent. zinc, 26 per cent. antimony, 21 per cent. tin, and 1 per cent. bismuth. This metal bath is heated above melting point, and the wire must remain in it until it has attained the same temperature as the metal, which, of course, is longer with thick wire than with thin wire. It is then taken out, and water is sprinkled over it. This process has discoloured it, and by giving it one more drawing, it is made bright again. If it need not be bright, then the hardening may be done after the last drawing.

There are other purposes for which wires of exceptional strength are required—notably for cranes, marine hawsers, mining, and bridges. We have seen a weight of 1 ton suspended from a steel wire of No. 8 gauge, to be used for deep-sea sounding.

Gold and Silver Wire. Gold wire is now seldom used. Its place is taken by silver-gilt wire. The gold is put on to the silver rod in the form of leaf, a piece of which 4½ in. square weighs about 18 grains. The gilded rod is then drawn out through steel dies, and, as it gets down to the finer gauges, through dies made from gems—diamonds, rubies, or sapphires. The amount of gold put on the silver rod is about 2 per cent. of the less precious metal, yet even this small proportion can be drawn out to extreme fineness. Twenty-four grains of gold in a silver wire have been drawn out to the length of 410 miles. The silver-gilt wire used for embroideries, laces, vestments, and uniforms generally contains from 1,500 to 2,500 yards to the ounce. Sometimes the so-called silver-gilt wire is really copper silver-gilt. A rod of silver, before gilding, is drilled and a rod of copper inserted. Then the gold is applied to the surface of the silver as already mentioned, and the three metals are drawn together, the attenuation

during the process being uniform, and illustrating the remarkable ductility of all three metals.

Brass and Copper Wire. The quality of brass wire depends upon the proportions of the constituent metals of which the brass is composed. A high proportion of zinc gives a light colour and a brittle and springy wire. For fine gauges of wire, and for weaving into gauze such as is used extensively in paper-making, a brass high in copper is used.

The old method of making brass and copper wire, and that still in extensive use, is to roll the metal cold between flat rolls until the thickness desired—depending upon the final gauge of the wire—is attained. This operation yields strips, which are then cut into thin rods, to be afterwards drawn into wire in the manner described for iron and steel wire.

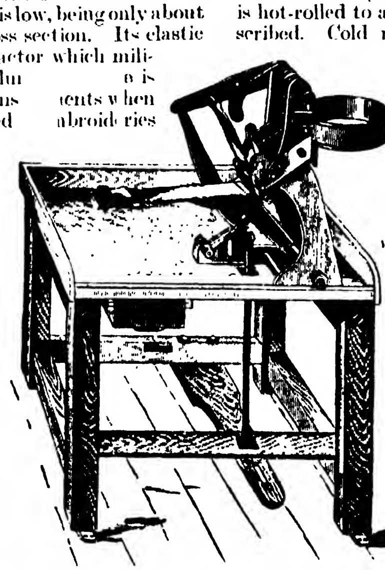
Aluminium Wire. Aluminium in its pure state has a restricted use in the form of wire. It is light, but its tensile strength is low, being only about 10 tons per square inch of cross section. Its elastic limit is also low, a further factor which militates against its use. Fine alu n is sometimes used for scientific ins ents when lightness is required, and is used abroid ries instead of silver wire. Aluminium bronze, however, an alloy of aluminium and copper, yields a metal high in tensile and elastic properties, being also a good conductor of heat and electricity, and inoxidisable. Hence wire of aluminium bronze has a wider sphere of usefulness than wire of pure aluminium.

Aluminium wire is used to some extent in electrical engineering. It is proposed to convey the electric current generated at the Victoria Falls on the Zambesi to the Johannesburg district by means of aluminium wires, and as we write a sample of the wire used for a similar purpose in America is on view at the Rhodesia Museum in Finsbury Circus, London, E.C. e aluminium electric cable is a "formed" w rope, with a central wire, surrounded by an intermediate layer of six wires, and finally by an outside layer of twelve wires, the entire cable having a diameter of 1 in. It is proposed to carry the Rhodesian cable on the top of steel towers 60 ft. high.

Wire of Rare Metals. The intrinsic value of platinum is very high, hence its use as wire is very limited. It can be drawn into very fine wire. It is employed in the manufacture of electrical apparatus and scientific instruments where the ability to resist oxidation, acids, and high temperatures is required. It cannot, however be used for electric glow lamps, as it fuses too readily. Osmium and tantalum are, however, rare metals which have recently been introduced into the manufacture of filaments for electric glow lamps. Their use, especially the latter variety, will probably extend. Special measures have to be adopted to reduce osmium to the form of wire [see page 2682].

Pins. Pin manufacture is an important British industry, the chief seat of which is Birmingham, where indeed are made about three-fourths of the quantity produced in the country. It is computed that 50,000,000 pins are manufactured every day, and the statement constitutes a comment upon human carelessness in small things. Pins are made from wire the size of the shank or body of the pin, and the wire is almost always of brass. The material must be soft enough to allow the head to be riveted up from the stem, and hard enough to serve its ultimate purpose without bending too easily. The brass from which pins are made by the best makers contains from 60 to 65 per cent. of copper, 35 to 40 per cent. of zinc, traces of lead and of iron, never aggregating more than ·5 per cent., and occasionally minute traces of tin, these last being impurities. For long years the standard composition for pin brass was two of copper to one of zinc, and indeed this mixture came to be generally known as "pin brass," but the slight saving achieved by reducing the copper percentage has caused that practice to be followed.

The brass ingot is usually about 2½ in. square, and is hot-rolled to about ⅜ in. diameter, as already described. Cold rolling is sometimes practised, but it requires a brass richer in copper, and is therefore more expensive. In either case the wire is drawn to its final size through draw-plates.



4. PIN STICKING MACHINE

Pinmaking. The illustration [3] on the preceding page will help to an understanding of the actual process of pinmaking. The coil of wire is placed on the revolving drum as shown. The end is led through a guide hole, and then between iron pegs, which straighten it and guide it to the machine. A sliding plier arrangement seizes the end of the wire, draws it forward, and pushes it through a hole in a small iron plate. Here a tiny hammer or punch "upsets" or thickens the end of the wire, thereby forming the pin head. The machine has been set carefully to the gauge of the length of pin required, and as soon as the head is formed a shearing blade comes into action and cuts off a short length of wire. This length of wire is a rough pin with a head, but without a sharp point. In a space of time infinitely shorter than we take to describe the movement the pointless pin falls into an inclined groove just wide enough to hold the pins suspended by their heads. This groove, when the machine is in operation, contains a row of pins suspended. A revolving cylinder with file teeth graduated from coarse at the entering end to fine at the finishing end operates upon the end of the suspended pins, which move backwards and forwards in the groove, and files the ends to sharp points. The short wires, perfect in form but far from perfect in finish, then fall from the lower end of the groove into a receptacle. The machine we have seen has turned out the pins at the rate of from 180 to 220 per minute.

Finishing Pins. The pins are still yellow brass. They must be whitened, or "silvered." But they re greasy, and must first be cleaned. They may be revolved or "tumbled" in barrels or cylinders with a solution of caustic soda. This cleans off all adhering grease. Then they are transferred to "kettles," or vessels heated by steam.

Metallic tin in fine powder is spread over them, some hot solution of bi-tartrate of potash is added, and the vessels are sealed up. The pins are allowed to boil for about four hours, when they emerge silvery and bright in their coating of tin. Then they go to revolving barrels or drums containing sawdust, and are tumbled about until they are dry and polished. The operator now handles them upon a tray. He agitates this tray, and thereby expels any dust which may adhere to them. Then they go to the final machine [4], final as far as the manufactory is concerned, and are put into rows, and issue as papers of pins. The machine that performs this operation is almost as ingenious as the machine that made the pins. The pins are placed in a sort of hopper, and the girl operator sweeps them with a brush into grooves that lead down to the rolls or strips of paper into which they are to be put. The machine creases the paper into the ridges required, and the operation of a lever causes the paper to come up to the rows of pin points, which are then pushed into their respective places in the paper. The papers are made to contain 100 to 500 pins.

Needles. The public are given to associate needle manufacture with pin manufacture, and if they have thought about the subject at all, imagine that the processes of manufacture are somewhat similar. This idea is a mistaken one; the processes are quite dissimilar. The manufacture of needles is a finer operation, and demands greater skill as it is not so dependent upon automatic machinery. Needles are made from a superior quality of cast-steel wire. This wire is delivered to the needlemaker in coils. A workman cuts this wire into short lengths, each length sufficient for two needles. These short wires are not perfectly straight, but have to be made so before anything else is to be done with them. The wires are taken in bundles about as big as can be compassed with the two hands, and an iron ring is placed at each end of the thick bundle. The bundles are heated in a stove, and then placed upon an iron table, where the workman rolls them backwards and forwards, still in the bundle, pressing a curved bar called a "rubbing knife" upon the body of the wires between the rings. This operation, which requires skill, makes the wires quite straight and regular by one wire rubbing against another under the pressure given.

5. STAMPING NEEDLE

Making Points and Eyes. Pointing is the next process. It is effected in an automatic machine, in which the mechanism holds the wires and presses them against a swiftly revolving grindstone, which forms the points and makes the needles ready for the eye-stamping machine. The process of pointing needles used to be fraught with very great danger to the health of the workmen, few of whom were able to work at their trade beyond the age of forty; but for the last two decades conditions have improved, and suction fans are made to carry the steel-dust and sand from the grindstone out of danger of inhalation by the workmen.

The stamp [5] is like a small drop forge, operated by a stirrup pedal. Taking in his left hand a bundle of wires, the stamper places them in rapid succession upon the lower die of his machine, and with his foot causes the upper die to descend with force. The dies form the heads, make beneath the needle-eye the short grooves that act as guides in the act of threading, and also almost pierce the eye itself. As many as 6,000 wires per hour can be handled by a skilled man. The needles are still twins, every wire being two needles, attached by their heads.

The press where the *eyeing* is done has a die similar to that of the stamping machine, but made so as to pierce the eye quite through. One by one, the double needles are placed upon the bed of the press [6], and the handle causes the die to come down. The holes are made, and as the tool retreats again the twin needles show a tendency to stick to it, but a special part of the mechanism pulls the wires from the die, which ascends to repeat the operation.

The stamp has left the head of the needle rough. Girls thread the needles upon a fine wire, and the result is what look like fine combs. The filer takes the "combs" in hand, and with his file, or with a flat grindstone, clears away the "rag," or burr, from both sides of the head. Now each wire is placed in a hand vice, and is parted in the middle—the operation of stamping having made the parting easy—and another treatment with the file makes the head smooth where the pairs have been joined.

Hardening and Tempering. The needles now go into an oven or stove, usually heated by gas, and are raised to red heat. They are then cooled by being plunged into oil, after which they are hard and brittle as glass, and quite useless as needles. They have been *hardened*. The tempering process, performed by the same workman who hardened them, consists in heating the needles up to about 600° F., and allowing them to cool gradually. Any needles that have become crooked during the process of hardening must be taken and straightened with a small hammer on an anvil, one by one.

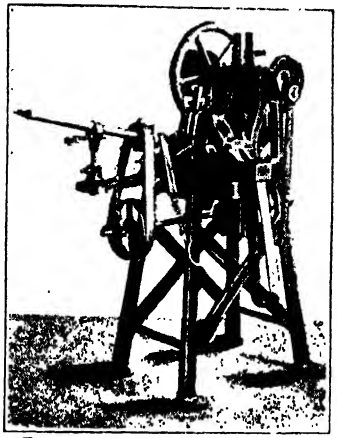
6. THE EYEING PRESS

The heads of the needles are softened by heat, and then follows the process of scouring and burnishing. The former alone takes about a week. Its object is to remove the dark coating of protoxide of iron which the needles have taken on as a result of the operations described, and to show a surface of polished steel. The needles are placed upon canvas strips laid in wooden troughs, and have poured upon them a mixture of oil, powdered quartz, and soft soap. The canvas strips are closed both at the sides and ends, and the sacks of needles are placed upon what is called the "runner bench," a table with boarded sides. A heavy wooden block works backwards and forwards on the bags, turning the needles and pressing them one against another in the gritty composition. Several times during the day, when the operation is going on, the needles are opened out and inspected, and finer grit

supplied. Finally, for the last scouring, what is known as "polishing putty" is put in. The needles are then taken out, boiled clean, and dried thoroughly in warm sawdust.

Finishing Touches. The needles must now be sorted out, for all these processes have made them of varied lengths. They are placed, with heads all one way, upon a narrow board in a row about one inch deep, and the long ones are removed by hand.

A drill is then passed through the eye of each needle, to make certain that there is no roughness that would fray the thread as the needle was being used. Then the finishing-room does its part to the all but perfect needles. Cylinders covered with leather buffs, upon which a polishing composition is put, burnish the needles. The workman handles each needle separately. The points are then ground a little, for the cycle of operations has blunted them slightly. An operator holds them against a stone mill for this purpose. Then the needles are rubbed between two pieces of buff leather to remove any moisture or stains. Finally, they are taken into hot store-rooms for some time, as a last precaution, and then they are made up into the familiar packets which we see on the market. This brief review of the processes of needle manufacture will make it hard to understand how the needlewoman can purchase needles for the small price at which any haberdasher or draper will be pleased to supply them.



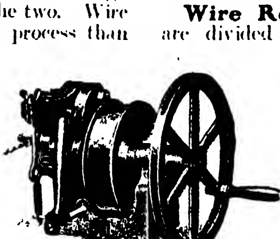
7. TACK AND TINGLE MAKING MACHINE
(Bond & Co Birmingham)

Wire Nails. The manufacture of wire nails is an enormous industry, which is, however, chiefly in the hands of German firms, who command the greater part of the world's trade in common varieties of wire nails. The functions of the wire nail machine is similar to that of the pinmaking machine, which we have already examined, although there is no great similarity between the two. Wire nail manufacture is a much simpler process than pinmaking. In the former case there are no elaborate pointing, polishing, and finishing operations to be gone through. The wire is fed into a machine in the coil, and is automatically straightened, cut into lengths suitable for the nails being made, pointed, and headed. The operations of cutting and pointing are performed at the same time. The end of the wire, as it enters the machine, is gripped by dies, cutters part it into suitable lengths, and the flat head is put on by a percussive or a pressing part of the mechanism. There are two types of machines, one of which makes the head by successive blows, and the other by pressure. The latter machine [7] is the better and the more generally used. Its output is much larger than that of the percussive machine. The output of a machine is from 100 to 300 nails per minute, according to size, and with mechanical means of yielding such an enormous output it is not surprising that the old-time nailer is extinct as a craftsman. Clout nails and wrought shoe nails and hobs, none of which are, however, made from wire, are the only articles in the category of nails which are still made by hand.

Wire nails range from 1 in. up to 6 in., and many thicknesses are made in every size. Almost all the wire nails used or manufactured in this country are made of round or oval wire, the proportions being about 5 per cent. of oval wire nails, or *brads*, used for door panels and other purposes, and the remaining 95 per cent. being round wire nails with the checkered heads. The oval wire nails have usually a *clasp* head, which is narrow, and owes its strength to its height instead of to its size in either direction laterally. The purpose of this form of head is to enable it to be sunk into the door-panel moulding, so as not to be visible in the finished door. In some countries square wire nails are the most acceptable variety. Obviously, any section of wire nail desired can be made by feeding the machine with suitable wire, and any shape of head can be given by equipping the machine with suitable heading dies. Small brass and iron nails for shoes are made in the manner described, but the sizes of such nails run from $\frac{3}{8}$ in. to 1 in. long.

Fig. 7 shows a machine used for this smaller class of work. Its particular purpose is for wire tacks and tingles.

Wire Coiling. There are numerous purposes for which wire coils are used. Fig. 8 illustrates a machine for either hand or power use. The wire coil may be seen issuing from the coiling gauge. The machine is simple in its use, and rapid in its output. More complicated machines make upholsterers' springs, which are made of steel wire coated with brass or copper, usually the latter. Such machines are automatic, making each spring narrow in the waist, as required, and cutting it off when finished.



8. WIRE-COILING MACHINE
(Sir James Farmer & Sons, Salford)

Wire Ropes and Cables. Wire ropes are divided into three classes: "laid ropes," "formed ropes" and "cable laid ropes," and there are important differences between them. The first has a central core of hemp or soft wire surrounded by six strands, each containing a similar central core. A formed rope, again, has a greater number of wires in its composition. Around the six wires forming the strand as used in the laid rope are placed another layer of wires, or, perhaps, more than one; otherwise there is no difference. A cable laid rope is used only for large diameters and is made by stranding six laid ropes together to form one rope.

Flexible Ropes. Wire ropes, or cables, are often required to be more flexible than is possible with only wire strands. Such ropes are necessary for marine purposes. The usual practice is to make a wire rope around a hempen core. Sometimes each individual strand of the rope has a core of hemp. The making of such composite ropes presents no difficulties if the working of the ordinary stranding machines be understood. The saving of both bulk and weight by the use of wire

cables is very great. According to Lloyd's regulations a hempen rope of 13 in. circumference and a wire hawser of 4½ in. are considered of equal strength. The former weighs 40 lb. per fathom and the latter only 15 lb. Wire ropes for marine purposes are generally made of galvanised wire and have usually hempen cores.

Manufacturing Wire Ropes. The manufacture of wire ropes and cables represents the largest and most important use to which wire is applied, and its use is ever increasing with the growing demand for all kinds of metallic ropes and cables. The last fifteen years have seen the introduction of many improvements in the construction of the machinery employed in the manufacture of wire ropes and cables. These improvements are the outcome of the ever-growing demand for better, stronger, heavier, longer, and more diversified wire ropes and cables. For many purposes, a great demand has sprung up for wire ropes and cables composed of a large number of fine wires, so as to render them more flexible, and to obtain the greatest possible certainty concerning their quality.

Many very heavy cables are being used in connection with mines, bridges, ropeways, and similar work, and these can be made only on very large machines; such machinery can make cables weighing up to 80 tons each in one length—that is to say, in the case of an 8-strand cable weighing 80 tons, each strand has to weigh ten tons, and the cabling machine carries 8-strand reels.

Considerable variety has been introduced into the manufacture of cables by the use of wire of irregular section, and machinery has been modified to facilitate the use of irregular-shaped wires. Generally speaking also, many improvements have been made so as to facilitate the employment of high speed in the running of cable machinery. At the present time, stranding and cabling machines are running about 50 per cent. quicker than formerly.

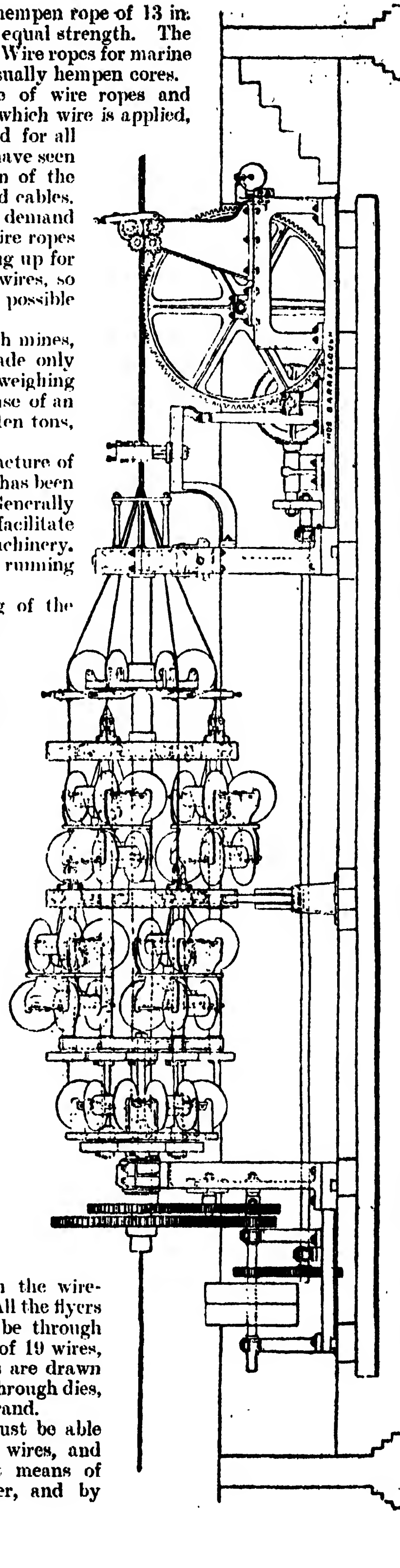
Wire Winding. The first operation is the winding of the wires on to the bobbins of the machines. This has to be done with care and regularity, so that the bobbins can contain their full capacity of wire, and also to ensure that the wires run freely from the bobbins. Wire-winding machines are made to wind simultaneously on to six bobbins if the bobbins are small, say of 5 in. to 8 in. diameter; if they are large, each winding machine is constructed to wind one bobbin.

Recent improvements have been introduced into the construction of these machines to make them automatic in action, so that whereas formerly one skilled man was required to attend to two machines, now one unskilled man can attend to seven machines.

Fig. **10** represents an improved wire-winding machine. During the passage of the wire from the reel to the bobbin it is not only kept constantly tight, but also in constant contact with a horizontal guide or traverse-pulley, furnished with a groove. This effects a regular winding-on of the wire, with the result that on each bobbin the maximum quantity of wire is wound, and in the most regular manner possible. The traverse motion can easily be regulated in order to adapt it to the thickness of the wire to be wound, and to the width between the flanges of the bobbin. A further important advantage results through the wire being treated with the greatest care in its passage from the ring to the spool. The traversing-pulley revolves in the same direction as the wire and runs at the same speed, so as to avoid all scraping or scratching, which is damaging in the case of galvanised or tinned wire.

Strand Forming. The next operation is forming the wire strands, some of which are made with a hemp core, and some without core. All the bobbins containing the wires to be used in making the strand are placed in the wire-stranding machine, each bobbin in a steel frame or flyer. All the flyers are fixed in iron rings, which revolve round a central tube through which the core passes. If the strand is to be constructed of 19 wires, the stranding machine must carry 18 bobbins. The wires are drawn from the bobbins with the utmost regularity, and passing through dies, they assume their proper position, and form the desired strand.

Stranding machines of the most modern construction must be able to make strands composed of a maximum number of wires, and be able to revolve at the maximum speed. The best means of attaining this is by combining several machines together, and by keeping their diameter as small as possible.



9. COMBINED WIRE-ROPE MAKING MACHINE—MAKES THE STRANDS AND THE ROPE SIMULTANEOUSLY (Thomas Barraclough, London)

Combined Stranding Machines. A growing demand exists for combined wire stranding machines, capable of running at high speeds and making strands composed of a large number of wires. The principal reason for this is that ropes and electric cables possessing, among other special qualities, much greater flexibility than formerly, are in ever increasing demand. These machines possess several important advantages, which we set forth by taking as an example a treble stranding machine composed of three sections to carry 6, 12, and 18 bobbins respectively.

Each combined treble stranding machine is capable of being transformed into three separate and independent stranding machines in such a manner that each section can work in either direction, make its own strand, and wind it on its own reel. Thus:

Section "A" can make a strand of 7 wires.
Section "B" can make a strand of 13 wires.
Section "C" can make a strand of 19 wires.

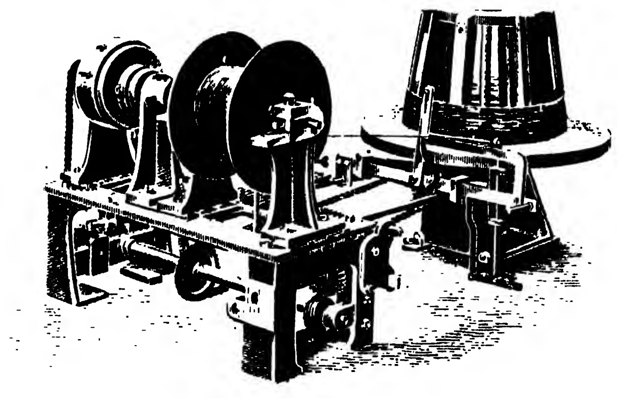
Each section can run at the full rate of the speed of which a machine of its size is capable.

The sections can be run semi-independently. Sections "A" and "B" can be run together to make 19-wire strand, while section "C" is simultaneously making a 19-wire strand; or sections "B" and "C" can be run together, making strand up to 31 wires, while section "A" is making a 7-wire strand. When all the three sections of the machine are combined, they can be run in either direction, and produce strands up to 37 wires, at the speed of section "C." The three sections, when combined, are able to make the strand by forming a core, say of 7 wires, putting round it a layer of 12 wires, and putting round it another layer of 18 wires. The three sections, when combined, are able to form a strand by carrying all the wires to the front lay-plate, and there combining them simultaneously into one strand of 37 wires.

These combined machines are not merely several machines placed one after the other, but are specially designed for the manufacture of multi-wire strands. If stranding machines of ordinary construction are placed one behind the other, the length of the combined machine is enormous. To avoid this, each section is furnished with its own draw drum, and, alongside it, its own winding-on apparatus, so that when each section is working as a separate machine, the three strands produced simultaneously are taken upwards, each passes round its grooved swinging pulley, then descends, and each one is wound on to its reels. Some machines are employed to make strands up to 61 wires by using a wire core of 7 wires, and are composed of:

Section "A" carrying 12 bobbins.
Section "B" carrying 18 bobbins.
Section "C" carrying 24 bobbins.

For telephone cables, combined machines are made to carry up to 224 pairs of wires.



10. WIRE-WINDING MACHINE

Wire Cabling. Wire cable machines are made both of vertical and horizontal construction. The former are constructed each with six, eight, or nine flyers to carry the strand bobbins, and, in addition, each machine has one central flyer to carry the core bobbin. The bobbins vary very much in size, and may contain each from 2 tons to 10 tons of strand.

Several important improvements have been made in these machines. For instance, the whole body of each machine, instead of revolving on one central step, now revolves on a series of steel balls, placed in special steel circular paths. This arrangement reduces very materially the power required for driving the machines, and does away with the annoyance and frequent stoppages arising from heating and wearing of the central step in the old style of machines. Each closing machine is furnished with an improved double-geared winding-on apparatus, working automatically with self-acting traversing motion for winding the finished rope or cable on to the reel.

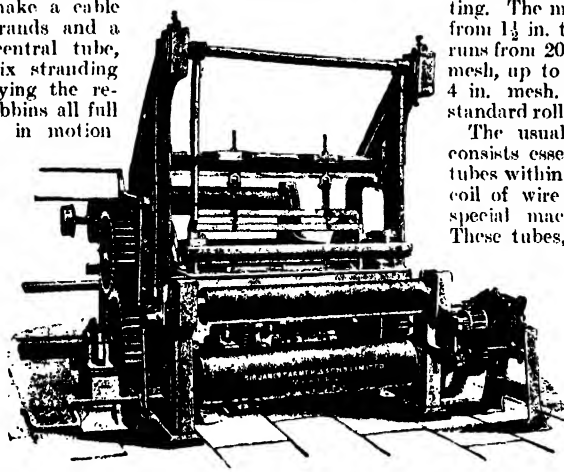
The horizontal wire rope and cable machines are constructed to carry from six to 12 steel flyers and bobbins. The body of such a machine is mounted on a powerful steel tube revolving in long bearings; the core passes through this tube; a stand is supplied for the back of each machine to carry the core bobbin. The rings of the body mounted on the tube run on anti-friction rollers, which are easily regulated, support the body and facilitate the running. The flyers carrying the bobbins are made of steel. The bobbins vary very much in size, say from a 5-cwt. to a 60-cwt. capacity. Each machine has a suitable winding-on apparatus, with reel, indicator, etc. To ensure the maximum speed, the cast-iron body rings are hooped with wrought-iron hoops, shrunk on hot, as a security against the danger of accidents.

Fig. 9 shows the longitudinal section of a Compound Wire Cable machine which makes the strands and lays the rope in one operation. It carries 42 bobbins of wire, up to No. 11 gauge, and makes in one operation a 7-strand cable, 3 in. in circumference and without any splice, whatever may be the length and weight required.

The driving is communicated from a headstock, by means of spur gearing, to a hollow central steel tube, 17 ft. 6 in. long, 6 in. external diameter, with hole through 2 in. diameter; this steel shaft runs the entire length of the machine to the lay-plate, and carries the whole of the stranding mechanism, and is made hollow to allow of the central core for the cable passing along the inside. By means of a sun and planet motion, the centre wheel of which is fixed to the steel tube, motion is conveyed to six bobbins, which carry the six central wires for the six strands, and these bobbins are carried by themselves on a separate ring. Then follow three other rings also placed on the central tube; between the

first and second rings revolve three stranding apparata, and between the second and third rings three other stranding apparata, all these six stranding apparata being driven by means of spur gearing fixed to the central steel tube, and motions are introduced for lengthening and shortening the lay of the wires in the strands. The six strands pass through dies so as to ensure perfect rotundity, thence over guide rollers and through the head of the machine.

After passing through the lay-plate, the six strands enter a set of dies, in the centre of which passes the core, and are thus formed into a cable. These dies can be set nearer to or farther from the lay-plate, according to the diameter of the cable being made. The finished cable passes five or six times round a draw drum 5 ft. in diameter, which is driven by gearing. An ingenious arrangement is attached to the delivery end of the machine, which, working by friction on the edge of the cable as it is being delivered, automatically records the exact length as it is being made. The operation of the machine will be understood from the above description, but it may be interesting to add that, assuming it is intended to make a cable composed of six strands and a central core, the central tube, which carries the six stranding apparata, each carrying the required number of bobbins all full of wire, being set in motion causes the six wire strands to issue from the six stranding apparata and to combine together. In their centre is placed the core of manilla, or hemp rope, which, having been previously saturated with tar oil, passes along the middle of the central tube and takes its place exactly in the centre, where the six strands combine around it, and thus form the cable.



11. WIRE-WEAVING MACHINE
(Sir James Farmer & Sons, Ltd., Salford)

Uses of Wire Ropes. The industrial uses of wire ropes are always extending. At the top of the tree are enormous wire cables for suspension bridges. Messrs. Richard Johnson & Nephew, Limited, of Manchester, recently made for a suspension bridge at Cincinnati, United States of America, two wire cables, each a mile long and each containing 52,000 wires from end to end. The total weight of the two is 500 tons and the breaking strain is 6,500 tons. Incidentally it is a source of national pride that an English company can compete successfully for such articles in a high-tariff wire-manufacturing country like the United States.

Ropes for winding purposes find their chief sphere for use in mines [see page 3766].

Certain cautions must be observed in the use of ropes for hoisting purposes. A steel rope is not so flexible as a hempen cable and the strength is seriously impaired if the pulleys over which the ropes run are of too small a diameter. Such ropes also should never be made to coil in more than one direction, as is sometimes done. To cause a wire rope to coil in two directions, one opposite to the other, is to subject it to an undesirable strain and to shorten the life of its efficiency by one-half. Ropes for hoisting purposes should be freely lubricated when in use.

Winding ropes for use in mines are usually about 4 in. in diameter, and the drums or pulleys upon which they run have usually a diameter of from 20 ft. to 30 ft.

Wire Netting. The trade in wire netting is very large. Yet it is little more than half a century old. In the 'forties of last century wire netting began to be made by cumbrous hand process, to describe which would have only a historical interest. It is with the wire-netting machine first invented by Mr. Barnard, of Norwich, in 1855, that we have concern. The wire generally used for netting is common annealed iron or mild steel wire. Wire-netting machines may differ in detail, but the principles of most are similar. They are invariably adaptable to make many widths of netting and many different meshes. The limits of width are from 1 ft. to 6 ft., and even up to 9 ft. may be purchased. The meshes obtainable run from ½ in. up to 4 in., the larger sizes being usually called "sheep" netting. The most common meshes are from 1½ in. to 2 in. The wire used runs from 20 and 22 gauge for ½ in. mesh, up to from 10 to 16 gauge for 4 in. mesh. In this country the standard roll of netting is 50 ft. long.

The usual wire-netting machine consists essentially of a number of tubes within each of which a tight coil of wire is wound, always by a special machine for the purpose. These tubes, which contain the so-called "helices" of tightly-coiled wire, have at their top ends semicircular pinions. Another series of wires is fed to the machine from bobbins, and are led through tubes also fitted with semicircular pinions. By a peculiar half turn and sliding motion, these tubes "waltz" about as the wire is pulled through the machine and rolled upon a cylinder. Suitable apparatus control the size of the mesh and the strand that forms the selvedge border.

Wire Cloth or Gauze. Wire woven into fabric is used in many industries. The paper-making trade uses large quantities, the gold-mining industry has need of wire gauge of special quality, and flour millers make demands upon the wire-weaver. Wire may be woven so fine that 40,000 meshes go to the square inch. This degree of fineness can be better appreciated by an illustration. The half-tone photographic blocks used as illustrations in this article have a surface made up of minute points. There are 14,400 of these points in every square inch, but the wire cloth mentioned above has almost three times as many holes as the half-tone block has points.

This degree of fineness is, however, unusual. The machine commonly employed for weaving wire [11] can produce a mesh of from two to 100 holes to the lineal inch—that is, of from four to 1,000 holes to the square inch. It is really a loom driven by power and is entirely automatic in action.

Continued

WHEATSTONE'S A B C SYSTEM

How Complicated Mechanism Produces Simple Operation. Double-current Working. The Cure for Capacity Troubles

By D. H. KENNEDY

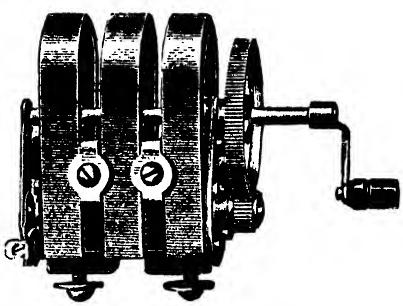
THE *communicator*, as the sending instrument is called, is made up of the generator, the contact maker and pawl arm, and the controlling keys. The generator [36], in modern forms, is the same as used in magneto-telephone sets. It is really an alternator [see page 1357] in its most simple form.

Three horseshoe-shaped permanent magnets with their similar poles together provide the lines of force for the field. Two soft iron pole pieces are provided, one for the north side and one for the south side, and their inner faces are hollowed out so as to allow the armature to revolve with only a very small air gap.

The *armature* is a shuttle-shaped piece of soft iron, H-shaped in cross section, on which is wound many turns of silk-covered copper wire. One end of the armature winding is metallically connected to the armature, and so is in contact with the magnets of the generator. The other end is connected to an insulated stud which is brought out at the end of the axle as shown in 37.

As already stated, each revolution of such an alternator produces two current impulses, one positive and one negative. Above the generator and immediately under the dial (already shown on page 4384) is placed the mechanism for controlling the sending of currents.

First it is necessary to provide that only one key shall be depressed at a time. This is arranged by the uses of an endless chain passing round a series of pulleys, one for each space, and adjusted so that the depression of one key forces all the available slack in between two pulleys. The depression of any other key will therefore be possible only in conjunction with the restoring of the first mentioned to normal. This is shown in 38, together with the means of adjustment.



36. COMMUNICATOR GENERATOR

Referring now to 39, the axle C, which is turned by the crank handle, carries the generator driving wheel, and also the bevel wheel D, which gears with the larger bevel wheel D_1. These wheels are proportioned so that fifteen revolutions of the armature, producing thirty currents, exactly coincide with one revolution of D_1.

Rigidly attached to D_1 is the disc K, with escape teeth cut round its periphery [40]. The wheel and disc together run free on the axle *d*. On the same axle, and immediately above the escape wheel, is a flat brass arm, A, carrying on its outer lower end a pawl, *p*, with a tail-piece, *t*, and two stop-pins limiting its play.

Two long, flat springs, s_1 and s_2, act upon the pawl; s_1, the stronger, presses it forward, causing it to engage with K, and so to be swung round. It will so continue until the tail-piece comes into contact with a depressed key; s_2 then moves the pawl outwards away from the teeth of K.

Above the rotating arm A there is still another arm, A_1, on the same axle. Above A_1 there is a conical steel spring which is pressed down by the adjustable collar, C_1, which is fixed at a suitable point on the axle. The upper extremity of the latter passes through a bearing and then through the dial, carrying on its end the pointer, fixed exactly over A. Returning to A_1, the *contact* arm, its outer end is normally held in the insulated position by means of the spring, S_3. When the tension of this spring is overcome it moves over and connects the generator to the line.

Now let us reconsider the sending of the word "Do," noting the behaviour of the mechanism. Normally we have the pointer at + and the arm A lying immediately beneath. The crank handle is turned and D and K revolve, but clear of A, which is held by the tail-piece lying against the lower end of key.

A_1 is also held in its normal position by S_3. Now we depress Key D. Immediately the pawl engages with K and the arm A and the pointer moves round. The force exerted by the conical steel spring pressing A_1 and A together is sufficient to overcome S_3; *therefore*, while A is moving round, A_1 is connecting the generator to the line and a current is sent out for each letter passed. When D is reached the projecting key engages with the tail end of the pawl, the latter disengages from K, arm A ceases to rotate, and the contact arm is therefore drawn back by S_3. The supply of currents to the line is thus interrupted at the proper instant, and the distant indicator needle will be at D. The same description, of course, applies to other letters.

The A B C Indicator. As in the Post Office standard relay, we have the large curved magnet, the two coils, and the two armatures fixed on one axle. Referring to 41, the arm, A, which takes the place occupied in the relay by the tongue, is arranged so that it causes the axle which carries the indicating needle to oscillate. By means of an escape wheel this oscillation is used to cause the axle, and therefore the needle, to rotate.

Fig. **42** illustrates the method by which this rotary motion is secured. E is an escape wheel with 15 teeth; $p1$ and $p2$ are light springs; $r1$ and $r2$ are small screws. When the armatures are actuated by alternating currents, the arm A [**41**] oscillates, carrying the centre of E from side to side. When it moves from the left side, as shown, P1 restrains its upper part, causing the under side to move, so that another tooth comes round over $p2$. A movement of the armature from right to left in a similar way results in a tooth moving forward under $p1$, so that two oscillations of the armature produce rotation to the extent of one tooth.

Zero Setting Handle. As signalling must always begin from +, it is necessary to provide for setting the indicator needle to zero. For this purpose a handle, H, is provided, the oscillation of which produces the same effect on the needle as do the signalling currents.

Combined Indicator and Bell. In the modern form the indicator is arranged so that it does duty as a bell to call attention.

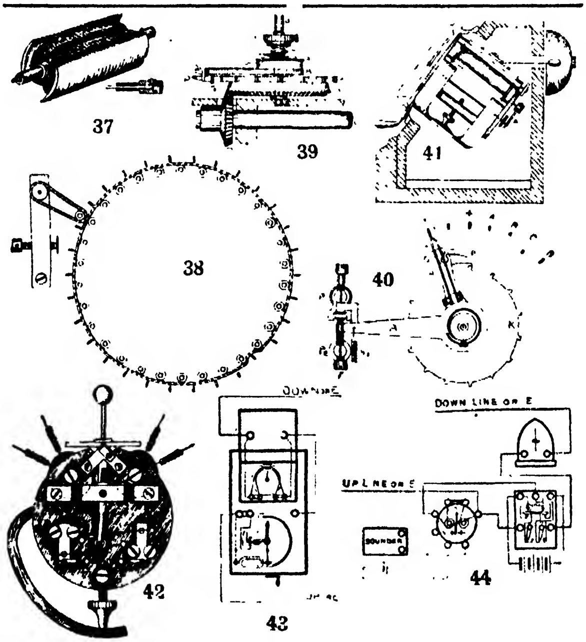
The four pole pieces of the coils are extended upwards. A light, bar-shaped permanent magnet is provided with soft iron T ends, as armatures, and has fixed to its centre a projecting bell hammer. This combination is arranged on pivots, so that it rocks from side to side under the influence of alternating currents. Bell domes are placed at suitable points to receive the impacts of the hammer. The arrangement is on the same lines as the magneto bell [see Telephones]. During actual work the hammer is clamped by a switch.

The resistance of the indicator is 250 ohms, and of the generator 800 ohms. Fig. **43** is a diagram of the connections.

Double-current Working. Let us take, for example, a single-current sounder circuit, and consider what occurs when we depress the key and connect the battery to the line. The first supply of energy goes to charge the line, and before this charge has reached a suitable value the distant receiving instrument cannot be actuated. Moreover, when we finish the signal and allow the backstop of the key to connect the line to earth, we leave the line in a charged condition, and this charge must escape to earth and leave the line clear for a second signal. On short aerial lines the time necessary for these charge and discharge operations is negligible, but on long lines, and more especially on long underground lines, the time is so considerable as to interfere with the signals.

Capacity. This difference between the long and the short line is in virtue of their capacities. The capacity of lines on single-wire circuits varies—firstly, directly as their surface, so that increasing either length or diameter increases the capacity; secondly, inversely, as their distance from earth; and, thirdly, in the case of insulated underground wires, directly as the specific inductive capacity of the dielectric or insulating material. Immediately attempts were made to work at high speed on long circuits this capacity effect caused trouble, but fortunately a simple cure was soon found.

The sending apparatus was modified so that instead of signalling being done by *currents* for marks, and *no current* for spaces, marks were made by a current in one direction and spaces by a current in the opposite direction. In other words, after charging the line, say, positively, to send the signal; at its termination, instead of allowing the positive charge to leak out comparatively slowly, the line is immediately charged negatively, the first part of the negative charge absorbing the positive, and altering the condition of the line in a much shorter time. Thus we have double-current working.



WHEATSTONE A B C MECHANISMS

37. Generator armature **38.** Endless chain adjustment **39** and **40.** Communicator mechanism **41.** Combined bell and indicator **42.** Indicator escapement **43.** A B C connections **44.** Double current sounder connections

The single-current key is displaced by a key which controls both poles of the battery, and is provided with a switch for connecting the line to the receiving instrument when the key is not in use for sending. Fig. 12 [page 4607] shows a double-current key, while **44** shows it as given in diagrams. Our receiving apparatus must be polarised, as is the P.O. standard relay. It is not necessary when working with double current to adjust the relay with a spacing bias. **Fig. 44** is a diagram of a double-current sounder circuit.

Continued

JOINERY

Beads. Doors and Door Frames. Hinging. Window Sashes and Frames. Movable and Fixed Sashes. Hinged Windows. Shutters. Skylights and Lanterns

By WILLIAM J. HORNER

THE work of the joiner is confined chiefly to neatly finished fittings and constructions that are not exposed to the weather. The wood used must be well seasoned, and not employed in pieces of large bulk, or trouble will subsequently arise through shrinkage. The preparation of parts, formation of joints, mouldings, etc., are now done to a large extent by machinery, so that, except for work on a small scale, the modern joiner is becoming restricted to assembling parts and fixing work in position.

Beads and Chamfers. These simple forms of ornamentation are very commonly employed in all classes of joinery. Examples of beads are shown in **1**, **2** and **3**. They are usually formed with a *quirk*, or groove, at one or both sides, as shown, the bead itself being flush with the surface it is formed on. Beads are usually formed on the solid wood, the operation of working them being called *sticking*, and the bead thus formed being said to be *stuck* on, as distinguished from being *planted* on, when it is made separately and attached. These terms are also employed in other cases where there is a choice between working out of the solid or attaching ornamental parts. When they stand above the surface, beads are usually planted on.

A *chamfer* is formed, as in **4**, to remove the sharp angle of a corner. When it is not planed the full length of the wood, but is rounded up, as shown, with an inch or two of the corner left beyond, it is called a *stopped* or *stop* chamfer. *Reeds* are a series of beads side by side [**5**]. *Flutes* [**6**] are the reverse of reeds, and are usually terminated as shown.

Special planes are used for the formation of surfaces that are not flat. Planes known as *hollows* and *rounds* are used for forming the hollow and rounded surfaces of straight mouldings, etc. They differ from rebate planes only in having curved soles. Fig. **7** shows the type of plane, in this case with a rounding sole for planing a hollow channel, such as one of the flutes in **6**. This kind of plane, however, has been giving place of late years to tools of the spokeshave type, fitted with fences, which adapt them for both straight and curved work. Their only advantage is that they are provided with sets of irons of different sizes and forms, so that one tool is thus capable of doing a great variety of work. Their bodies are of iron and their soles flat, the cutter projecting below to the necessary amount. Beads are formed with cutters of the required shape for making both bead and quirk; reeds and flutes with cutters for forming a certain number of rounds or hollows side by side. Chamfers are often cut with a special plane, but it is not so necessary as in the case of beads. A return bead [**3**] is formed with the same plane as used for a single bead [**1**].

Doors. The methods of constructing these are typical of all other work in which large surfaces of wood are required. There are three main types of door, with numerous minor distinctions. The simplest form is a *ledged* door, like **8**, but without the diagonal braces. With the diagonal braces it is known as a *ledged and braced* door. The next advance on this is a *framed and braced* door [**9**]. In this, a frame is mortised and tenoned together, and the boarding is tongued and grooved into it flush with one face of the frame, the frame itself being more than twice the thickness of the boards, or *battens*, as they are called. Of this frame, however, only the two uprights and top rail are the full thickness of the door, and it is only into these three members that the battens are tongued. The bottom and middle rail, and also the braces, are thinner, being flush with the back of the frame, but nailed on to the back surface of the battens, and also fitting with barefaced tenons into the uprights, or *stiles*, as they are called. The door thus resembles an ordinary ledged door, but with the addition of a frame round top and sides. This prevents shrinkage in width, because the rails keep the stiles at a fixed distance apart, and the stiles are too narrow to shrink appreciably. The other type of door is that employed for ordinary dwelling houses and for articles of furniture. It is called a *panelled door*.

Panelled Doors. Fig. **10** shows a very simple form of this door, consisting of a frame with only one panel. In the example given, the grain of the panel is supposed to run diagonally to brace the frame, but this more for appearance than because it makes much difference. In a small door of this class the panel would probably be in one piece, with the grooves cut across it to relieve its plain appearance. In larger doors and panelled screens, the panels would be made up of narrow pieces and the grooves would indicate joints. Figs. **11 to 13** show ordinary forms of joints suitable both for a door like **10**, and for the battens of ledged doors. Sometimes the bead or chamfer is formed only on one face of the door, but only in the roughest class of work is the joint ever made flush and plain on both sides. On a plain unbroken surface, joints are too conspicuous, and look very bad if they come open through shrinkage.

Panels are nearly always thinner than the door frame, and though they are fitted loosely to permit of shrinkage or swelling, it is seldom advisable to make them more than 11 in. wide. In most doors, therefore, two or more panels side by side, are necessary to make up the width. In height, also, the frame generally needs at least one intermediate rail to tie the stiles securely and also to give solidity where the lock or handle is placed. In an ordinary room door, therefore, there are at least four panels. All the horizontal members of the frame are called *rails*, but the middle upright, instead of being called a stile, is a *muntin*. It is fitted into the rails with stub tenons only. Fig. **14** shows the construction of an ordinary door. All the inner edges of the frame have a groove ploughed in them about ½ in. deep, shown dotted, to receive the edges of the panels. These, of course, have to be slipped into the grooves as the frame is put together. The stiles and rails of a door are named according to their position. The stile to which the hinges are attached is called the *hanging* stile, because the door hangs by it. The other, to which the lock is attached, is called the *lock* stile, or *closing* stile. The rails are known as *top*, *bottom*, and *lock* rails, according to

their position. When there are four rails, as in **15**, the first one below the top is called the *frieze* rail.

Proportions. The top rail is about the same width as the stiles, 3½ in. or 4½ in., and the lock and bottom rails are about twice that width. In ordinary house doors the top edge of the middle rail comes about halfway in the height of the door. Stiles always run the full length of the door, and rails are tenoned between. Tenons at top and bottom are haunched, as in **14**, and to prevent breaking out during wedging, the stiles extend an inch or so at top and bottom. These extensions are called *horns*, and they are allowed to remain until the door is being fitted in its place, when it is, of course, necessary to trim them off. Owing to their great width, bottom and lock rails have their tenons divided into pairs, as shown in **14**. In cases where a mortise lock has to be let into the door, the tenons there are generally made double, as well as paired, so that four distinct tenons occur on that end of the lock rail. A *sash* door [**16**] is fitted with glass in its upper part, and the stiles are often reduced in width, as shown. A *double margin* door [**17**] is employed where great width is required, and continuous rails are considered unsightly. The middle stiles are continuous from top to bottom, giving the appearance of two doors meeting in the middle. The door, in fact, is made in separate halves, which are afterwards united by a tongued and glued joint, and also keyed by three pairs of folding wedges through the stiles, as shown in elevation and plan in **17**. Large doors of this class are sometimes additionally strengthened by having a strip of flat bar-iron let into the top and bottom edges, the recess and iron being stopped a little short of the full width of the door, so that the ends of the iron shall not show. *Sliding* doors may be either battened or panelled according to their situation. Fig. **18** is an example of a large sliding door with an opening in it for a *wicket* door. Where the braces cross, they are supposed to be halved, but in many cases diagonal braces are not used, or short ones are fitted between. The ends of diagonal braces should always butt against rails. If they are allowed to come against stiles, they tend to force the joints open. A *jib* door is one made to form in appearance an unbroken continuation of the wall in which it occurs. It closes flush with the wall, and skirting or dado to correspond with that on the wall is put across the door. A *dwarf* door is a very low one, of the character used for church pews. Revolving doors, used sometimes for public buildings, are constructed on the principle shown in **19**. They are framed and panelled and their edges have projecting strips of rubber or felt to make a close joint and prevent draughts. They revolve on pivots at top and bottom, and are arranged to fold if the passage is required open.

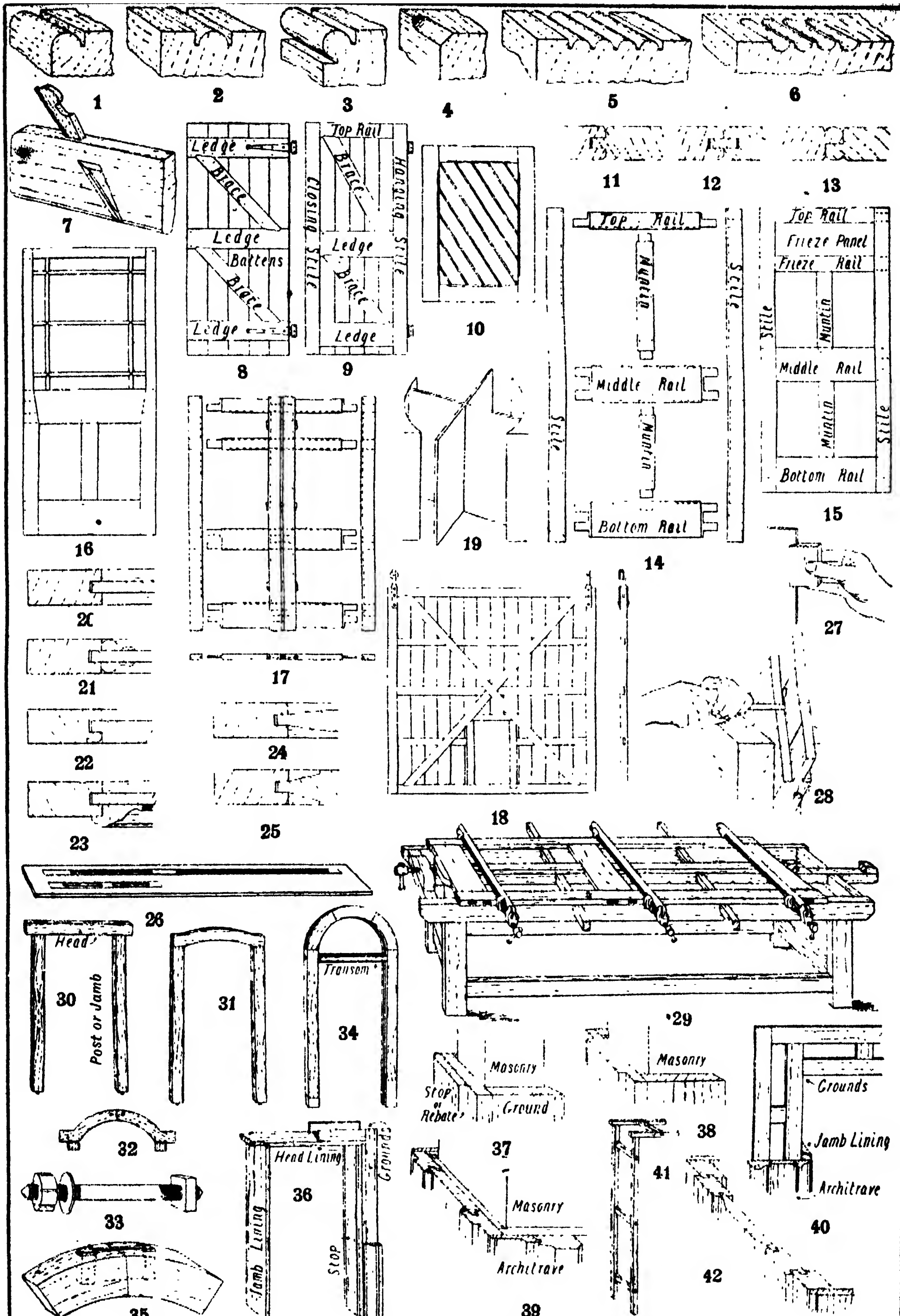
Panels and Mouldings. Figs. **20** to **25** show in section different forms of panels and mouldings employed in panelled doors. The simplest form of panel is a thin sheet of wood flat on both faces, and of the same thickness as the grooves into which its edges fit [**20**]. The same kind of panel may be employed but with various forms of moulding round its edges. Moulding may be put on both sides, as in **21**, or only on one. Owing to difficulties with shrinkage, mouldings running across the grain of panels are sometimes omitted and mouldings with the grain only are put on. The moulding in such cases is usually only a bead, and the panel is called a *bead butt*. When continued round the panel, the latter being flush with the frame, as in **22**, it is called a *bead flush*. Mouldings may be separate and attached after the door is framed together, or they may be worked out of the solid either on the stiles and rails of the door, or on the edges of the panels. When a panel is flush with the frame on one side, as in **22**, a bead is employed which may be on either the panel or the frame. In **22** it is shown on the frame, which is the best way. When on the panel, it is necessary to mitre a separate bead in, across the grain, and this prevents the panel from shrinking, or rather forces it to split if it shrinks. A *bolection* moulding stands above the surface of the frame, as in **23**, and fits round the edge it comes against, so that shrinkage does not produce an open joint. Besides the sunk and flush panels already noticed, we have the *raised and fielded* [**24**], the *raised, sunk and fielded* [**25**], the *raised, sunk and moulded* (which only differs from **25** in having a moulded sinking instead of a straight one), and the *chamfered*, in which the chamfer of the raised panel is continued to the middle of the panel.

Doors are made of hard or soft wood, according to the quality required. Oak and walnut are considered the best woods for high-class doors, both external and internal. For common doors ordinary deal is used for either situation, or pitch-pine for a slightly better class of door. For good interior doors, mahogany is popular. In some cases they are veneered.

Marking Out. Before beginning to make a door, it is marked out in full size longitudinal and transverse sections on what is called a *rod* [**26**]. This is a thin drawing-board of suitable length and width. It is generally about ⅜ in. thick, without battens, so that both faces can be used. These rods are kept for permanent use when doors of similar dimensions and character are frequently wanted. The lengths of stiles and rails, positions of mortises, etc., are transferred directly from this to the planed-up lengths of wood, the parts being laid on the drawing on the rod, and distances carefully marked from one to the other with knife or pencil; thus avoiding risk of inaccuracies by measuring with a rule. In parts which have to correspond with each other, as, for instance, the stiles, one is marked from the rod and the marks squared across it, and then the other stile is cramped to it, and the marks continued across that. The rods contain as many sectional views as are necessary to give all particulars of the door. Face views of ordinary doors are not required.

Fitting Together. The parts are all marked to show how they go in relation to each other, and the thickness of mortises and tenons is gauged from the same face of each piece. The mortises and tenons may then be cut and the grooves for the panels ploughed. The width of the grooves may be either the same or less than the mortises, but not more, or the haunches of the tenons will be too thin to fit it. A similar groove is ploughed in a block of wood, which is used, as in **27**, to see that the edges of the panels fit it correctly. Fig. **28** shows how a pair of tenons are cut by hand. The method is applicable to many other cases besides that illustrated. A hole is bored with a centre-bit in one corner, and a keyhole saw inserted and a cut made along the root of the tenons. The two cuts down the tenons may be made with a handsaw.

Each joint is tried together separately, and a straightedge laid across to see that the parts are in line. If they are not, the tenon or mortise must be eased to bring them so. Then the entire frame



JOINERY

1. Single-quirked bead 2. Double-quirked bead 3. Return bead 4. Stopped chamfer 5. Reeds 6. Flutes 7. Type of plane for hollows and mouldings 8. Ledged and braced door 9. Framed and braced door 10. Panelled door 11-13. Joints suitable for boarding of ledged doors 14. Method of framing an ordinary panelled door 15. Door with five panels 16. Sash door 17. Double margin door 18. Sliding door 19. Revolving door 20. Flat panel 21. Moulded panel 22. Bead flush panel 23. Bolection moulded panel 24. Raised and fielded panel 25. Raised, sunk and fielded panel 26. Rod 27. Testing thickness of panel edge 28. Using a keyhole saw 29. A door cramped on a special bench 30. Simplest form of door frame 31. Segment head 32. Segment head in two parts 33. Handrail bolt 34. Semicircular head 35. Hammer-headed key joint 36. Plain lining for an interior door 37. Plain lining 38. Double rebate 39. Framed jamb and architrave 40. Framed grounds with framed architrave 41. Skeleton lining 42. Double-framed lining

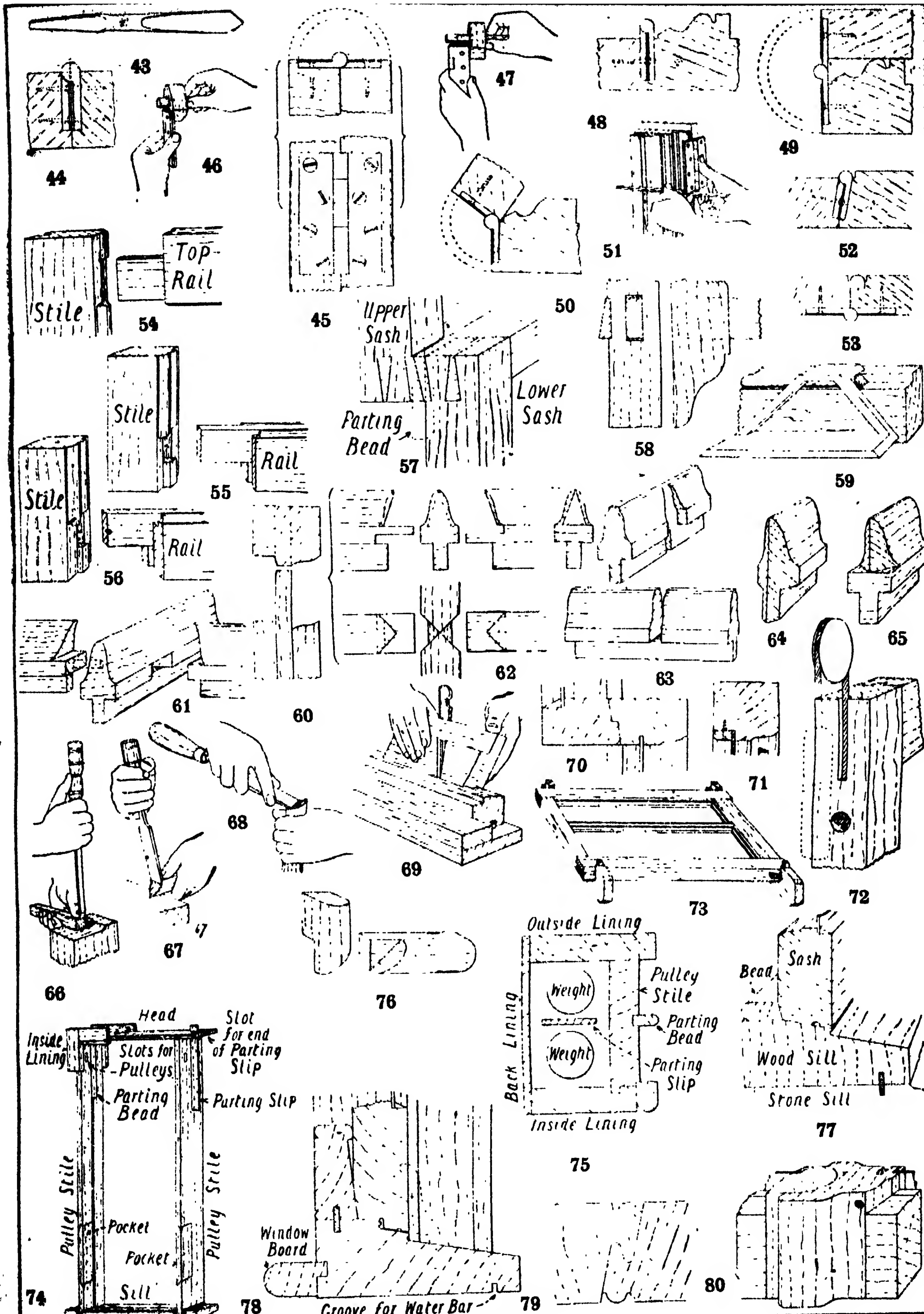
should be tried together to see that it does not wind. For gluing up, a special bench, as shown in **29**, is very convenient. It has a longitudinal cramp for the muntins, and separate cramps can be used across the stiles. Cramps are employed as a simple means of pulling the shoulders of the joints up tight until the wedges have been inserted, after which the cramps may be removed and the door laid aside for the glue to dry. Glue joints of this kind cannot be made as perfect in character as rubbed joints previously described, partly because the parts cannot be rubbed and properly cramped, and partly because the glue cannot be applied to all the parts quickly enough. Where large numbers of doors are made, machines in which all the parts are cramped instantly by a simple movement of foot lever and hand screw are employed. Window sashes are put together similarly.

Door Frames. As doors cannot be fitted directly into an opening in masonry, it is necessary to have a wood frame or lining provided with a rebate or stop to receive the door. In its simplest form such a frame is made as in **30**, the projecting *horns* at the top being built into the brickwork, or if this cannot be done conveniently, the frame is constructed without them. The *head* piece is always fitted on top of the posts or *jambs*, because the frame is then better able to sustain weight than if it was tenoned between. Door frames are sometimes made with a *sill* as well as a head, but more frequently they are open at the base, like **30**, and dowelled, or socketed into stone or concrete, as the case may be. The stop is usually formed in common work by nailing strips ½ in. thick round the inside of the frame, allowing for the thickness of the door. Fig. **31** is an example of a frame with a segment head, the head being cut from a solid piece. When the depth is so great that a very wide piece of wood would be required, and the grain would consequently be very short, the head is formed in two pieces, as in **32**, held generally by a handrail bolt. These bolts were formerly employed chiefly for uniting lengths of handrailing, but have been found very useful for many other purposes in joinery. The position of the bolt in the wood is dotted in **32**, and the bolt itself is shown in **33**. Recesses are cut in the wood to a suitable depth and in correct positions for the nuts, and the bolt hole is bored from the joint into each recess. The bolt is provided with a loose nut at each end, one being square, and the other, which is turned when tightening up the bolt, is round, and provided with slots, so that it can be turned with a screwdriver, or more properly with a special tool called a *handrail punch*. Dowels are generally inserted in addition to the bolt. Fig. **34** is a frame with a semicircular head. This may be bolted also, but is better built in segments, as shown, the front being in three segments and the back in two. The transom is tenoned into the jambs below the segments. The curved portion is united to the jambs by a hammer-headed key joint shown in **35**. This is an alternative to the handrail bolt, but is slightly more rigid, though, of course, taking more time to fit. The key is made to fit closely along the sides, but is slack endwise until tightened by the wedges. This pulls the joint together. In **34** the bottoms of the jambs are shown fitted into cast-iron shoes instead of provided with dowels. These shoes are made of the same section as the jambs, and the ends of the latter have to be shouldered down to fit into them. The shoes are sunk a little way into stone or concrete, and the wood is thus protected.

Linings. The frames for internal doors are generally thin and of a boxed-up character [**36**], the wood being carried not only across the interior faces of the opening, but also for some inches over the wall surface on both sides. This provides both a gauge for levelling the plaster up to, and a wood surface for the further attachment of *architraves*, as the moulding round a doorway is called. The wood within the opening is called, at the sides, the *jamb* lining, and at the top the *soffit* lining. The wood on the faces of the wall, forming a foundation for the architrave, is called the *grounds*. Its back edge, against which the plaster comes, is undercut or grooved to form a key for the plaster. When the widths of the pieces of wood exceed 6 in. or 8 in. they are not made solid, as in **36 to 38**, but are framed as in **39**, **40** and **42**. It is best both in solid and framed linings to allow a little air space between wood and masonry by backing the linings with narrow strips about 2 ft. apart. Generally the grounds are not treated in this way, but when their width is considerable, are made in an open framework as in **40**. Strips are shown behind the jamb and soffit lining in **36**, with their ends supposed to be dovetailed into the grounds. A strip is also shown behind the jamb lining in **38** and **39**. Another method is to make a skeleton lining [**41**], to which jambs, soffit, and grounds are attached. When the width of the lining is considerable it is sometimes framed, as in **42**.

Fixing Wood to Masonry. In doorways and other situations where wood has to be attached, breeze bricks are generally built in at intervals and into these nails are driven. When this is not done bricks or stones have to be plugged, or nails or suitable iron attachments driven in or built into joints. The simplest and best way to plug is to drill a hole 2 in. or 3 in. into the brickwork or stone, and drive a wood plug tightly in. Into this a nail can be driven. The hole should not be larger than necessary, because a needlessly large plug may shrink and become loose. Half-inch diameter is enough for most purposes. The kind of bit used is shown in **43**. Sometimes square holes are chipped with a narrow chisel. Sometimes mortar is chipped out of a joint and a thin, wide plug driven in, or a piece the size of a brick and ⅜ in. thick may be built in. Sometimes plugs are tapered and cut winding, but nothing holds better than a tightly-fitting parallel plug. Frames inserted after walls are built are tightened by long, thin folding wedges in place of backing strips.

Fitting a Door. The door to be fitted in place is supposed to be a little larger than required. The frame into which it fits is supposed to be square and parallel each way, but if it is not so, the door must be made to correspond with it. If the frame is square, it should measure the same each way when tested diagonally, or a large square should fit all corners alike. Assuming it to be square a strip may be cut to the length and another to the width of the opening. From these lengths the required reduction for joint allowance must be made. If the door and frame have to be painted a slight amount must be allowed for that, and if put up in summer something extra must be allowed for the swelling that will take place in winter. Plenty of clearance should always be allowed at the bottom and as little as possible at the top, because the door will tend to sink a little from its own weight. If it has to be reduced much in size it is best to mark lines all round on one face at equal distance in from the edges, and plane down to these. The ends should be planed, or *shot*, first, because



JOINERY

43. Smith's drill for boring brick and stone 44 and 45. Ordinary method of fitting butt hinges 46. Setting a gauge to depth of required recess 47. Setting a gauge to width 48 and 49. Knuckle of hinge projecting to enable door to clear moulding 50. Knuckle too far in, causing door to bind against moulding 51. Ascertaining correct distance for hinge 52. Hinge tilted to bring knuckle into line with bead on one side 53. Hinge attached to faces instead of edges of hinged members 54. Joint between sash rail and stile with mitred moulding 55. A scribed moulding 56. A moulding part mitred and part scribed 57. Dovetailed joints in meeting rails 58. A stile prolonged to avoid a haunched tenon 59. The use of a mitre templet 60. A rail and sash bar mortised and tenoned 61. A joint between bars which cross each other 62. Tenons of sash bars overlapping 63. A halved joint 64. An end mitred preparatory to cutting a scribed joint 65. The moulded portion mitred for scribing 66-68. Methods of cutting scribed joints 69. Method of planing a sash moulding 70. Joint between meeting rails 71. Glass held in place by a bead 72. Attachment of balance weight to sash 73. Cramping a sash 74. A sash frame 75. Section through a casing 76. A bead stop-mitred 77. Section through a sill 78. A double weathered sill 79 and 80. Joints adapted for the meeting stiles

there will then be less risk of damaging the corners in planing the end grain of the stiles.

Hinging. Hinges should be attached to the door first, and then the door held in position while screwing to the door frame. The usual method with ordinary butt hinges is to sink them into each surface as in **44** and **45**. To ensure a close joint at the hinges, the hinge flaps generally have to be sunk very slightly below the surface of the wood, but if too much is allowed the wood will meet and bind before the door is closed properly. The simplest way is to set a gauge direct from the closed hinge as in **46**, taking half or slightly less than half the thickness over the two flaps, which when parallel with each other are slightly apart. This is gauged on the door and frame at the places where the hinges are to go. The width of the recesses may be obtained similarly by setting a gauge, as in **47**, to the width of the hinge from edge to centre of pin. The hinges are then laid in position on the door and their lengths marked with a knife. The recesses are cut out with a chisel and the hinges screwed to the door, care being taken to insert the screws square with the surface, so that their heads will not appear tilted when they are in. With the flaps open the door is placed in position against the jamb, the hinge lengths marked on it, recesses cut, and one screw inserted in each hinge. If the door works properly the others may then be put in, but if not the required adjustments can be made before further holes are bored.

In some rather exceptional cases the hinges are fitted to stand out as in **48**, so that the door may be fully opened, as in **49**, without binding against moulding when still only partly open, as in **50**. The amount to which the hinge must stand out is ascertained by measuring from a straightedge as in **51**. The distance the centre of the hinge pin stands beyond the face of the door and jamb must be only *half* the amount measured, because when the hinge is opened the centre of the pin comes half-way between door and jamb, throwing the door out to twice the measured distance. Hinges with their knuckles standing out in this way leave a wide crack between jamb and hinge stile of the door when the latter is open. Hinges with the centre of the pin flush, as in **44**, leave the minimum. If hinges are set further in than this the corners of the wood must be removed to enable the door to swing at all. Hinge pins must always be in line with each other, or a door cannot work properly.

Hinges are sometimes tilted, as in **52**, to throw the knuckle to one side so that it corresponds with a bead on one or other of the pieces of wood. When edges are too thin to have butt hinges of sufficient strength attached, hinges are put on the faces of the wood instead, as in **53**. The hinges used are a little wider than butts, and are known as *back flap* hinges. The *cross garnet* hinges used for ledged doors [**8**] are also put on the faces but are not let into the surface. There are other varieties of hinges and methods of hanging doors which are employed in special cases.

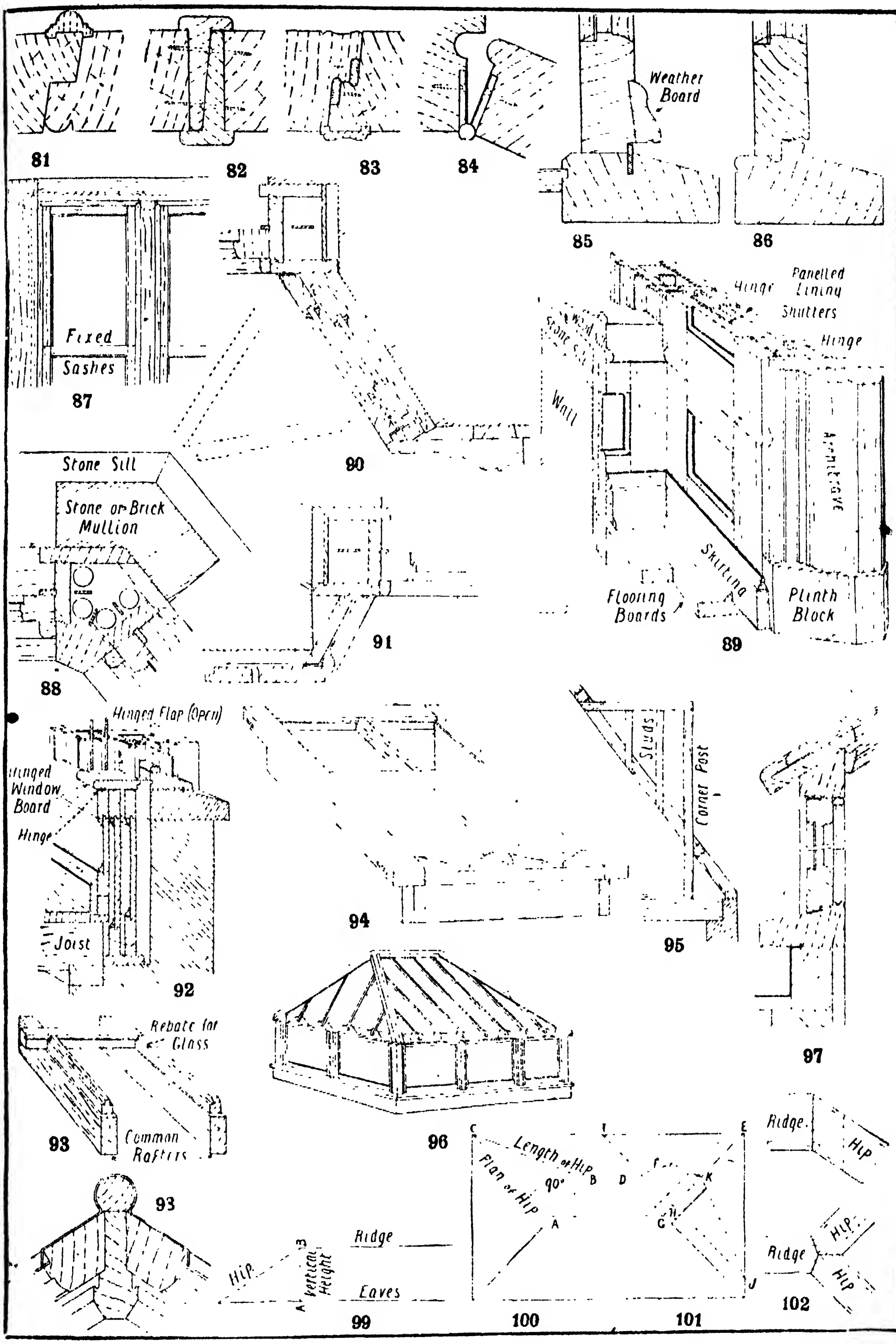
Windows. Windows may be either fixed or made to open, either on hinges or by sliding. In the first case all that is necessary is a solid wood frame fitted in the wall opening to receive the glass. In the second the glass is contained in an inner frame or sash which fits within the outer frame. In vertically sliding sashes the outer frame must have its sides cased to contain balance weights. There are also some patented improvements on ordinary sliding sashes which dispense with weights and enable the sashes to be easily removed for cleaning the glass.

Joints in Sashes. Sashes are mortised and tenoned together as in **54** to **56**. The *meeting* rails of an ordinary pair of sashes, being shallow, are dovetailed to the stiles as in **57**, or a tenon the full depth of the rails is employed by prolonging the stile in the form of a bracket as in **58**. In **54** the moulding is mitred. In **55** it is scribed, which does not result in an open joint if the wood shrinks. In **56** it is part mitred and part scribed, which avoids the feather edge of wood necessary when one part is made a scribed fit round the other. Mouldings are mitred with a chisel guided against a mitre templet, which is placed on the work, as in **59**, and generally cramped. These templets can be made of wood. The one shown is supposed to be of metal, in skeleton form merely for lightness. Thick sashes are sometimes jointed with double tenons, or the single tenon is supplemented by tongues on each side.

When sash-bars are inserted they are tenoned into the stiles and rails as in **60**. In the bottom rail, which is deeper than the rest, they are stub-tenoned. Where they cross each other they are generally fitted as in **61**. Sometimes a dowel, as shown dotted, is inserted in addition; and sometimes only a dowel is used, the bars merely butting together. Sometimes the tenons are reduced in thickness and lap over each other as in **62**. In this example the bars are shown mitred instead of scribed. In **63** they are shown halved together, but this latter method is suitable only for mouldings with a broad, flat top.

Scribed Joints in Sash-bars. The simplest method of making a scribed joint in a sash-bar, or other moulding, is to mitre the end as in **64**, and then remove the mitre by cutting transversely with gouges and chisels back to the outline, or *sight* line, where the mitred portion finishes. This gives the correct outline for meeting another member of similar section. As a tenon usually has to be formed on the end, the actual practice is to mitre and then scribe only the moulded portion of a sash-bar as in **65**. Fig. **66** shows the method of using a gouge in cutting a scribed joint. A scribing block to fit the moulding is necessary to cut on, otherwise the under edge of the moulding would get split away in using the gouge. Another method not always practicable is shown in **67**. In this case a chisel is used and no scribing block is necessary. Fig. **68** shows still another method of paring a curved portion with a chisel without the use of a block at all. This also is not practicable in some cases, because a projecting portion behind would prevent the chisel from being used in that way.

Construction of Sashes. In ordinary sashes which slide vertically the vertical bars are continuous, and the horizontal ones fitted between, this being the best arrangement for resisting the stresses and shocks to which a vertically moving sash is subject. In sashes hinged like doors the reverse method is better. The thickness of sashes is usually about $1\frac{7}{8}$ in. The stiles, and also the top rail of upper sashes, measure about the same in width as in thickness. Meeting rails are about half the depth, and the bottom rail about twice. It is not often that mouldings of sashes and bars are planed by hand, but the method is shown in **69**. The plane must be of the form required—generally what is known as a *lamb's tongue moulding* is employed. The meeting rails, on the side where they



JOINERY

81-83. Joints adapted for the meeting stiles of casements **84.** Hinge joint of a casement **85** and **86.** Sills of inward opening casements **87.** Arranging weights where mullions are too narrow to contain them **88.** Mullion of a bay window **89-91.** Arrangements of folding shutters **92.** Sliding shutters **93.** Simple form of skylight **94.** Skylight **95.** Arrangement of timbers for a dormer window **96.** A lantern light **97.** Details of lantern light **98.** Details of ridge **99-101.** Method of finding length and backing of hips **102.** Joints of hips and ridge

come in contact with each other, have to project beyond the face of the stiles, because the latter are separated by a bead. The joint between the two meeting rails may be plain bevel, like **57**, or a better method is to step them, as in **70**, which prevents a knife being inserted from the outside to open the catch. To keep the rails flush on the underside, as in **70**, the lower one is grooved for the glass instead of rebated. In all other parts the glass fits into a rebate, and is held by a bead [**71**] or by putty.

The best way of attaching the cord for the weights is shown in **72**, but sometimes the cord is merely nailed into an open groove ploughed in the stiles. In **72** a knot fitting in a hole in the side of the stile prevents the cord from pulling out. The groove may be either open its entire length or preferably closed for a portion, as shown. The cord should extend 12 in. or more down the sash. It is carried up over small pulleys in the upper part of the stiles of the window frames, and weights are suspended by it inside the casing. Fig **73** shows a sash wedged up in wood cramps specially for the purpose.

Frames for Sliding Sashes. A perspective view of an ordinary frame with parts removed is shown in **74**, and a section through one of the sides or jambs, with the weights inside, is shown in **75**. The bottom, or sill, is invariably solid, and of teak or oak sloped outwards to throw off wet. The top may be solid also, but frequently it is of thin material, as in **74**. The lower ends of the stiles are rebated into the sill and tightened by a thin wedge in the rebate, which is tapered to fit it [**74**]. The upper ends are either housed or tongued into the head, as shown. In good modern work all parts of the jamb casings are rebated together. The pulley stile is generally tongued on opposite corners, as in **75**, because the outer lining extends solid beyond it, while the inner has a loose bead, which necessitates keeping the groove farther back. This bead, and also the parting bead in the middle, are not attached till the sashes are inserted in the frame and it is necessary to detach them again to get the sashes out. The inner head, therefore, should be screwed in place and fit into a rebate. It is always made slightly to overlap the joint between stile and inner lining. The parting bead should fit in a groove, and is generally held by brads. The outstanding faces of the meeting rails of the sashes have to be cut away to clear the parting bead. A thin back is attached to connect the two linings, and a parting slip is required between the weights to prevent them from striking each other or getting entangled. Its upper end fits in a slot in the head, and a brad or wood pin is put through the projecting end to suspend it. Sometimes it is attached at the back as well, but generally it hangs loose [**74**]. For convenience in getting at the weights when necessary without pulling the frame apart, openings called *pockets* are made, and closed by *pocket pieces*, shown in **74**. It is not necessary to have these openings the full length of the weights, because the latter can be slipped in or out in an inclined direction. When situated as in **74** they are concealed when the lower sash is shut. Very often they are made central in the casing, and the parting bead between the sashes must be removed before the pocket piece can be taken out. The chief objection to making it as in **74** is that it is slightly more weakening to the pulley stile. The bead round the inside of the frame may be either plain mitred, or stop mitred, as in **76**. The parting bead is required only on the pulley stiles, but is sometimes carried across the head of the frame also.

Sills. The under edge of the lower sash is bevelled to fit the slope of the sill, as in **77**, and the inner edge of bead and sash should be bevelled also, as shown. If a plain unbroken joint were made between sash and sill, water would get through by capillary attraction. This is prevented by making a groove called a throat in the under edge of the sash rail [**77**]. The sill is also stepped and throated at the outer face of the sash. Between the wood sill and the stone sill a thin strip of iron is inserted like a tongue [**77**]. This is called *a water bar*, and prevents water from penetrating beyond it. Sometimes a step is formed in the joint between sash and sill, as in **78**, and occasionally a weather-board, as dotted, is added also. In **78** the bottom rail of the sash is made extra deep, and the inside bead replaced by a deep bar. The sill and head are nailed to the stiles, and the inner, outer, and back linings are nailed also.

Hinged Windows. These, when hinged to the jambs like doors, are called *casement windows*, or, if they are carried down to the floor, *French casements*. As no space for balance weights is required, the frames in such cases are solid, like door frames. The sashes in any case do not differ essentially in construction. The usual plan is to have two sashes meeting in the middle, sometimes arranged to open outwards and sometimes inwards. The meeting stiles come together direct without the interposition of a post, the joint between them being one of the forms shown in **79** to **83**. The most popular is the hook joint [**79**]. On the Continent the joint shown in **80** is preferred. Fig. **81** is about the simplest form of joint possible. In **82**, pieces of hard wood are screwed on to the stiles. In **83**, the joint is complicated by grooves and beads to shut out draught. In all these cases the meeting edges are at a slight angle instead of square with the casement, so that they separate and come together without friction. Fig. **84** shows how a bead and groove is often arranged at the hinge stile to prevent draught and entrance of water.

In French casements the bottom rail is made extra deep, and sometimes the lower part of the sash has a wood panel. Casements opening inwards are more troublesome to make watertight at the base than those which open outwards. One method is shown in **85**, in which a metal tongue stands above the surface of the sill. Another is shown in **86**. In this case there is no metal, but a channel is formed inside the stop to collect condensed water, or water which gets beneath the door. Holes are bored at intervals, as dotted, to conduct the water away. There are also various forms of patented water bars for inward-opening casements.

Fanlights and other small windows may be hinged either at top or bottom, or be pivoted at or near the middle of the stiles. The frames and sashes of these are all very simple.

Mullions. These are intermediate posts between sashes, and are necessary in windows of great width, and at the angles of bay windows. In both of these kinds the side sashes are often fixed, and only the central ones made movable, the former usually being narrow compared with the central sashes. As it is desirable to keep the mullions as narrow as possible, the cords for the weights are often carried over the fixed sashes [**87**] to avoid boxing up the mullions to contain them. In bay windows this is scarcely practicable, and the weights are arranged in the mullions, the outer portion of which is often masonry. Fig. **88** shows an arrangement of weights in the mullion of a bay window in which all the sashes are hung, the weights being

consequently four in number. An alternative is to make two separate boxings in each mullion similar to those in ordinary frames. In bay windows the sill and head of the frame have to be jointed at the mullions where the angle changes. Half-lap joints are employed for this purpose in the head, and sometimes in the sill, but a mitre joint is often preferred for the latter, secured by handrail bolts and tongue.

Shutters. These may be made in flaps, hinged together to fold into boxings at each side of a window; or they may be large panelled frames, arranged to slide either vertically or horizontally; or a number of separate shutters may be employed as was formerly the usual method of protecting shop fronts. For this latter purpose revolving shutters winding on a drum are now the most popular, but as they are constructed chiefly or entirely of metal, the joiner is concerned only with fitting them into place. The first mentioned kinds are framed and panelled in the same way as doors.

In **89**, folding or boxing shutters are shown folded into a boxing at the side of a window, the panelling below the window board matching the shutters. In **90** a two-flap shutter is shown in a splayed boxing, and the dotted lines show it partly drawn out. In **91** a shutter is arranged to fold against the wall, with no boxing. The dotted lines show it closed over the window. The rule joint, when the shutter is turned back against the wall, has the appearance of an ovolo moulding. Folding shutters are sometimes arranged on the outer side of windows, but the usual practice is to have them inside. The joints between flaps are always made to overlap by means of rebates, as shown. Fig. **92** shows the most popular form of sliding shutters. They move vertically, and are balanced by weights, similarly to sashes. They drop into a space beneath the window board, which is hinged as shown. A hinged flap is provided to cover the grooves and cords in the stiles when the shutters are down. Before drawing them up, this flap must be opened and turned back between the shutters and sash frame. One shutter goes right to the top, covering the upper sash, and the other covers the lower sash, the shutters being secured by a catch or thumbscrew through their meeting rails, which overlap each other an inch or so. Horizontally sliding shutters are sometimes employed, and slide in rails attached to the wall, outside or inside the window.

Skylights. The simplest form of skylight is glass fitted on the roof [**93**]. It fits in a groove at the top and a rebate at the sides, the bottom being left free to throw off water. For the same reason, if more than one length of glass is used, the sheets must overlap. In **94** a frame intended to fit into a trimmed space in the rafters is shown. The glass is inserted in the same way, but a bottom rail is provided for it to rest on. The surface of this rail is recessed as shown, to allow condensed moisture from the under-side of the glass to escape. The bars are stub-tenoned into the top rail, and usually notched into the bottom. The under edges of the frame are throated, and sheet lead is employed to cover parts where water might penetrate. In the best work, channels are provided beneath the glass in the sides of the bars and frame, to conduct condensed moisture.

Dormer Windows. For these [**95**] a trimmed space is provided in the rafters, and the window timbers are built into this. The corner posts, which represent the jambs of the window frame, are shown continued down to a joist, the inner surface beneath the window being boarded or lathed, and plastered over. Another plan is to let the lower ends of the posts bear on the trimmer or on a purlin. The studs and capping pieces are notched to fit the rafters.

Lantern Lights. These [**96**] are glazed constructions built either on a flat roof or on the summit of an ordinary roof. The slopes are usually hipped, and the sides provided with windows, either pivoted or hinged at the top. An alternative is to fit the sides with louvres, which may be either slats of wood or pieces of glass fixed at an angle in the frames in Venetian blind fashion. In flat roofs lantern lights rest on the timbers which trim the space. In sloped roofs queen post trusses are generally utilised, so that the corner posts of the lantern light form a continuation above the queen posts. The interior below the windows is generally panelled or boarded to cover the trimming timbers. Fig. **97** is a vertical section showing a usual arrangement, the windows in this case being hinged at the top to open outwards. Fig. **98** is a section through the ridge. In many cases the frames are fitted together without a separate ridge and hips. Where the latter are employed, as in **98**, their depth cannot be quite the same because of the angle at which they meet. As these parts are usually moulded, this is important, because the moulding of hips and ridge must be of different section, to enable them to correspond with each other at the inclined joints. The adaptation of one to the other will be dealt with further on, when treating of mouldings.

Length and Angles of Hips. As neither a plan nor an elevation of a roof can give true plans or elevations of the hips, these have to be obtained by geometrical methods. Fig. **100** represents a plan of one end of a hipped roof, such as the lantern light in question, and on it the actual length of the hip is developed at C B. Fig. **99** is an elevation of the roof from which the vertical height, A B, is taken, and projected from A to B on **100**, at right angles with the plan line of the hip A C. A line drawn from C to B gives the actual length of hip on its upper, or longest edge. The angle at B is the angle required to fit a vertical joint at the end of the ridge as in elevation **102**.

In some cases the top edge of ridge and hips have to be backed—that is, a double angle, as at K [**101**], is formed to correspond with the two planes of the roof which meet along the line of the member. In the ridge this angle is simply 30°, or whatever the roof slope happens to be. In the hips the angle must be obtained by the method shown in **101**. The hip length DE is first developed as in the previous figure, and then a point, F, is taken at any position on the line DE, and from this a line is projected at right angles to cut the hip line, GE, at H. Through H a line is carried at right angles, cutting the roof edges at I and J. With H as a centre, and radius HF, an arc is drawn to K. Lines from I to K, and J to K, give the angles of the hip backing. Fig. **102** is an elevation and plan of the junction of ridge and hips. At their lower ends the hips are notched on to the head frame, the corners of which are halved together. The sill is generally mitred and bolted. The posts are stub-tenoned into sill and head. The sill rests on a stout frame called a curb, which in turn rests on the trimming timbers of the roof below.

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SCIENCE AND SEA FISHING

State-aided Investigations that are Helpful to Fishermen Examination of Plankton. Marked Fish. Can the Sea be Depleted of Fish?

By Dr. J. TRAVIS JENKINS

OF late years much attention has been given to the application of biological and hydrographical investigation to the elucidation of problems connected with the sea fisheries. Schools of "fishery science" have been established, notably at Bergen and Kiel. Marine stations have been erected and equipped with the latest and most up-to-date apparatus for the study of applied marine biology, and practically every European country with a sea coast has one or more biological stations.

Institutions for the *hatching* of sea-fish are springing up around the coasts of Northern Europe and America, and some are already in full working order. They exist in England at Piel and Port Erin, and in Scotland at Aberdeen.

An International Council. For the last five years an international council of scientific men has been engaged in the study of the causes that affect the harvest of the seas, and an enormous sum of money has been expended. The central laboratory is established at Christiania, and the office of the central bureau is at Copenhagen. Each country has, in addition, its own laboratories, steamers, and a trained staff of naturalists, hydrographers, chemists, and physicists, all working to a common end. Voluminous reports appear from time to time, and as the results to be obtained may have an important bearing on the fisheries, especially with reference to future legislation, it is well for the intelligent fisherman to learn something of the methods employed by expert scientific men, and the results which have up to the present been obtained.

Considerable attention is now being devoted to the *physical*, as distinguished from the *biological* conditions which obtain in our seas. The methods of observation which were first of all practised by the famous Challenger expedition are being now amplified and applied to the determination of those changes in the physical condition of the seas which may reasonably be supposed to affect the presence of fish, and consequently the success or otherwise of the fisheries.

Physical Character of Sea Water. The characters of sea-water (apart from the plankton, which is separately considered) that are investigated are the *temperature, salinity, density*, and *gaseous contents*. By means of the first three data it is possible to trace the movements of large bodies of salt water, and to determine at given seasons of the year whence the water in our seas—the North Sea, English Channel, and Irish Sea, for instance—is derived. The movements of shoals of fish, such as the herring and anchovy, may possibly be correlated with the movements of bodies of water of a certain temperature and density. It is claimed that the anchovy fishing in the Scheldt is closely connected with the temperature of the sea, and that the arrival of the autumn herring off the Norwegian coast corresponds with the appearance of water of high temperature and medium salinity. At present these observations are carried out on the special steamers subsidised by the various Governments.

How the Sea is Analysed. The methods are briefly as follows: Soundings are taken to determine the depth and nature of the bottom; observations of temperature are made at the surface and at varying depths. Samples of the floating organisms are collected at the surface and at various depths. The temperature, pressure, and humidity of the atmosphere are also noted. Samples of water are also collected for analysis. The results are then collected and deductions drawn at the shore laboratories. Charts are published showing the lines of equal temperature (*isotherms*) and lines of equal salinity (*isohalines*).

It has been found that during the year 1903 the waters in the English Channel were derived in February and May from the Bay of Biscay, in August from the Irish Sea, and in November from both sources. North Sea water is derived from three main sources: (*a*) North Atlantic water of high density enters chiefly from the north-west: (*b*) Baltic water of low density enters as a surface current from the Skagerack; and (*c*) North Sea water of medium salinity. There is also what is known as Bank water forming a fringe to the coast line. It consists of a mixture of Atlantic and Baltic waters. There are various seasonal changes in the inflowing and outflowing currents, which prove that the North Sea fishing grounds are subject to periodical variations with respect to the water covering them. The ultimate bearing of these hydrographical observations on sea fishery problems is for the future to decide. They are still being carried on, and it would be premature to criticise the results until further information is at hand.

Drift Bottles and Surface Currents. The determination of the influences which affect the distribution of floating bodies has been largely accomplished by means of *drift bottles*. Strong, short-necked bottles are weighted with a small quantity of sand, so that they are immersed with as little of the neck protruding as possible. Each bottle has enclosed in it a stamped postcard addressed to the laboratory from which the experiments are initiated. The postcard has a printed statement on it requesting the finder to fill in information as to the date and place of finding, and to post the card. It is found that in a somewhat circumscribed area, such as the Irish Sea, about one in every three bottles is picked up, and the postcards returned with the requisite information. A number of bottles being weighted and made watertight by means of cork covered with paraffin-wax, a special voyage is made on a scientific steamer, and the bottles are thrown out at intervals of five minutes or so along certain lines which have been previously selected as likely to furnish important results. The rate at which the steamer travels being known, the distances at which the bottles are dropped overboard can be marked off on a chart. As the postcards return to the laboratory the journeys made by the bottles can be traced. Some of the bottles are picked up very soon, others perform remarkable journeys. The effect of tidal currents

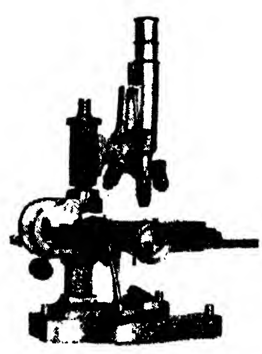
and the wind on the distribution c ce organisms is in this manner estimated. the problem has a practical bearing, as will b een later, in determining the most favourable ality for the *planting* of the fry from marine hat s.

The Plankton Investigations. A word that is frequently used in all discussions on sea fishery matters is *plankton.* All organisms which merely drift and are consequently at the mercy of the wind and tide are included in the plankton in contradistinction to those animals which, like fish, are capable of independent motion, and are therefore able to move against a tide or current. The *plankton* has been studied for a number of years, and its constitution is fairly accurately known. It consists of minute plants such as diatoms; various animalcules, small crustacea, especially those known as *copepoda,* the larvæ of free-swimming young, stages of various worms, crustacea (crabs and lobsters), mussels, cockles, oysters, and other shell-fish, and the floating eggs and larvæ of most of our food fish, the only notable exception being the herring, the eggs of which sink to the bottom, and develop there.

11. THE HENSEN VERTICAL NET
a. Conical headpiece
b. Fishing part of net
c. Bucket. *d. e. f.* Supporting rings

Now, the plankton, apart from interesting facts which will be discussed later, is of considerable importance, insomuch as it serves as a direct source of food supply of some of our most valuable fish, notably the herring, pilchard, sprat, anchovy, mackerel, and others. There can be no reasonable doubt that the supply of these important fishes bears a direct relation to the amount of plankton present in the ocean.

The Collection of Plankton. The plankton is collected by means of fine-meshed nets of silk bolting cloth, which are known as *tow nets,* having for their object the fishing out of plankton from a definite volume of sea-water. Of these nets the most successful is the vertical plankton net invented by Hensen [11]. This net, which is shaped like an inverted truncated cone, is lowered perpendicularly in the water to a given depth, and then raised to the surface also perpendicularly. By this method a cylindrical column of water filters through the net, and its planktonic constituents are captured.



12. MICROSCOPE USED IN PLANKTON INVESTIGATIONS

Quantitative Examination of Plankton. Now, the volume of this cylindrical column of water can be calculated since the filtration capacit of the net can be calculated and the depth to which the net is sunk is known, as is also the area of the net opening. This being known, the number of organisms ptured in the column of water through which the net has fished can be ascertained, and thus the contents of a given volume of sea water are known. The catch is next preserved in some suitable medium, such as *formaline* or *spirits,* and then it is subsequently estimated in the laboratory. There are four chief methods of estimating the contents of the catch—by *volume,* by *weight,* by *chemical analysis,* and by *enumeration.* For the latter, a special form of microscope [12] is used, having a large mechanical stage, which can by means of two screws be rotated in any given direction. The stage is ruled with fine lines cut by means of a diamond, and these lines divide the stage into squares. Consequently, it is a simple though a tedious matter to enumerate the constituents of a given volume of plankton.

Important results have been deduced from this method of enumeration, more especially with regard to the floating fish eggs. Take, for instance, the Eckenförde fishery in the West Baltic. This fishery for cod and plaice is carried on over an area of about 16 sq. miles, and there are on an average in January, 30; in February, from 45 to 50; in March, at least 60; and in April, 50 floating eggs of cod and plaice for every square metre of surface (a square metre equals 1·196 sq. yd.). These eggs take on the average about fifteen days to develop under the conditions which obtain in the West Baltic, so that the numbers above recorded must be doubled in order to give the number occurring per month under the square metre of surface water. This gives 370 eggs from January to April.

Determination of Intensity of Fishing. Now it has been calculated from a nine-year average that the number of cod and plaice annually caught by the fishermen of this district would, if allowed to remain in the sea, have produced 110·5 eggs per square metre of urface water. This, added to the 370 above, gives a total of 480·6, which represents the number of eggs that would have been produced from all cod and plaice, captured and free, yearly for each square metre of surface water. As a consequence $\frac{110\cdot6}{480\cdot6} = \frac{1}{4\cdot4}$ gives the fraction of the total quantity of adult cod and plaice actually captured, or, in other words, man captures for his own consumption about one-fourth of the total number of adult fish in this locality in the West Baltic. This estimation has been confirmed in a remarkable manner by the marked-fish experiments which are now being carried on in the North Sea by the International Council.

Marked-fish Experiments. Plaice are marked [13] with a numbered brass label attached to their bodies by a silver wire and then liberated. The active co-operation of the fishermen is secured by means of a system of payment of rewards for marked fish returned to the laboratory, with information as to date and place of capture. A large number of such marked fish have been returned to the laboratory at Lowestoft, and it has been calculated that trawl fishing in the southern part of the North Sea has caused an appreciable reduction in the numbers of the larger plaice of 10 in. in length and upwards, this reduction amounting to from 20 to 30 per cent. of the total population of this size in one year. This corresponds very closely

with the estimate of 25 per cent. derived years ago by the study of the plankton along quantitative lines.

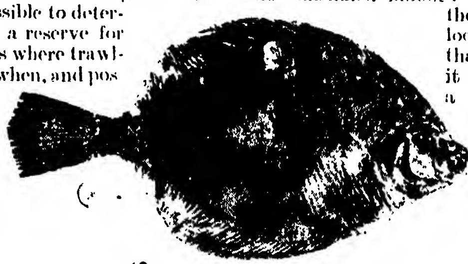
Other results from fish-marking experiments may be briefly mentioned here. The extent and nature of the migration of plaice, dabs, and soles, is one of the chief results to be noted. In the southern part of the North Sea plaice migrate from the inshore to the offshore grounds, in spring and summer months the general direction being a northerly one. Larger fish move quicker and further than smaller ones. It is, perhaps, rather dangerous to attempt generalisations of too broad a nature, based as they are at present on rather insufficient evidence, but there seems to be a winter migration of all plaice above 9 in. in length, towards the south.

Practical Bearings of Migration. Young flat-fish live, as is well known, for the most part, in shallow inshore waters called *nurseries*, and some of the largest North Sea nurseries are those off the Dutch coast. The facts as to the summer migration tend to show that the English plaice fisheries to some extent depend for their supplies on these inshore grounds. On the west coast certain nurseries are closed to all kinds of trawling on account of the large proportion of undersized fish met with; there is a closed area off Blackpool, for instance. If large numbers of plaice are marked and liberated in these closed grounds, it is obvious that it will be possible to determine how far they serve as a reserve for neighbouring fishing grounds where trawling is permitted; and where, when, and possibly why these young fish move into deeper waters.

Can the Sea be Depleted of Fish? One of the vexed questions of the sea fisheries of recent times is that of *over-fishing*. It would, perhaps, be more correct to say that the question of over-fishing has been with us for some considerable time, but that it has only recently become acute. The question can best, perhaps, be put in the following form: Can man, by his efforts, so upset the balance of Nature as to render further fishing unprofitable? That there must be some reason for supposing the answer to be in the affirmative would seem to be an obvious deduction from the numerous Acts of Parliament—and local by-laws passed in pursuance thereof—which have for their object the regulation of the sea fisheries. The various restrictive enactments which have for their object the protection of immature fish, or the prevention of destructive or wasteful methods of fishing, have all been passed as a result of the outcry against over-fishing and the alleged depletion of the sea. Restrictions as to the sizes and conditions under which fish may not be removed from a fishery, the regulation of implements of fishing, and the enactment of close times, all have resulted largely, but not entirely, as a consequence of the alleged vanishing of the harvest of the seas.

Statistical Evidence Wanting. If the deterioration of the fishing grounds is a fact, then one would naturally expect to find evidence of it in the statistical returns which have been furnished from year to year by the Government departments concerned. Unfortunately there is reason to believe that the statistical evidence has not in the past been collected with sufficient care to render any results obtained from its analysis reliable; and even with six years of the twentieth century gone, we have no more certain statistical evidence of over-fishing than was available at the time of the Royal Commission of 1863, when the Commissioners found the fisheries were not only not deteriorating, but were, on the contrary, capable of improvement. As regards methods of fishing in vogue at that time, there can be no reasonable doubt of the accuracy of this finding. But since then, the extreme development of trawling, and latterly the invention of the otter trawl, and the enormous annual output of steam fishing boats, have introduced new factors that it would not be wise or safe to ignore.

Statistical evidence being unavailable, we have to examine another scientific method, which consists of making observations by means of a special fishing boat or steamer on certain grounds at periodic intervals. Against this method very grave objections can be urged. Every practical fisherman knows that whereas one vessel may make a splendid catch another not five or even two miles away may catch nothing.



13. A MARKED PLAICE
This fish was liberated off the River Mersey on Nov. 12th, 1901, and recaptured in the River Lune on Dec. 2nd, 1904

Fishing is Skilled Labour. Fishing is not unskilled labour: more is to be credited to the personal experience and local knowledge of the skipper than is generally supposed, and it by no means follows that a trawl shot at hazard in a given locality can be relied upon to give a fair average sample of the number of fish even for a very limited area around that spot. Only extremely limited areas can be satisfactorily investigated by this method. While there are undoubtedly many practical problems which can only be satisfactorily investigated from a specially equipped steamer—such as, for instance, the determination of the vitality of undersized fish caught in a trawl, or the relative destructiveness to young fish of various-sized meshes—we would advise caution as to the acceptance of deductions as to over-fishing, based on evidence accumulated from one or even a few steamers.

Collecting New Statistics. With the discovery of new fishing grounds off the Icelandic coast, in the Bay of Biscay, and even so far distant as the White Sea and Morocco, there is no cause for surprise in the fact that the gross quantity of fish landed in the British Isles shows a continual and gradual increase. At the same time the quantity of fish on and near the British territorial waters may be on the decrease, and evidence of fish caught in or adjacent to these waters is urgently needed. Steps have been taken by the Board of Agriculture and Fisheries for the careful and accurate collection of statistics of fish landed from what may be called home waters, and in addition the actual catches of vessels of a certain class are separately recorded. There can be no shadow of doubt that this is the only reliable method of obtaining evidence for the regulation of the fisheries.

Continued

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MAKING HORSE COLLARS

Back Harness. Cruppers for Cart, Van, and Saddle Harness. Breeching and Straps. Cutting Horse Collars. Making the Collar Body

By W. S. MURPHY

THE horse collar is the piece of harness next to the bridle; but because the work of making the back harness belongs to the same class as the latter, we may take it first. The back harness consists of several pieces, which are made separately and then joined together. In the centre, and forming the backbone of it, is the *crupper;* the crupper terminates in a round loop called the *dock;* through the crupper pass a pair of straps named *loin-strap* and *hip-strap* respectively; on the ends of these, at both sides, are the tugs connecting the crupper with the breeching; last is the breeching itself, going round from loin to loin behind the horse. In constructing the back harness, the worker has to exercise a sense of proportion. Accurate measurement is the first essential; but, in addition, the harness-maker is called upon to use his judgment. Like all animals, horses vary in their proportions, and what might suit one horse may be altogether unsuitable for another, though the difference between them may be imperceptible to the casual observer. The gradations from what we call a light to a heavy horse are very close. Our measurements have been calculated for the average size of horse. Variation for special cases may be proportioned on that basis.


13. HORSE-COLLAR MAKING

Cruppers. From one end of the broad strip of leather designed for the cart harness crupper, cut out a semicircle; narrow the other end to 2 in. in breadth; race and crease it along the sides and ends; edge, black, and polish the creases with hot irons; prick it for nine stitches to the inch. Shape a piece of leather $8\frac{1}{2}$ in. by $\frac{7}{8}$ in., double the sides over and sew to within about 2 in. of each end; black, round, and rub it, flatten the ends. Under the points of the semicircle at the termination of the crupper lay the ends of the rounded piece, and sew them together, forming the dock.

Crupper Lay. Cut the crupper "lay" 1 in. narrower than the body; turn in one end 10 in., and beat it flat; at the other end turn down 2 in., and narrow for a buckle $1\frac{1}{4}$ in. broad; cut a hole for the buckle. Across the broad end run a line about 2 in. from the point, a cross line $\frac{1}{4}$ in. beyond the point of the turned leather underneath, and a third line $2\frac{1}{2}$ in. nearer the buckle. On the lay make two lines of creasing and stamp them with a hot iron. Add another line inside, forming oblong rectangular panels, with spaces between for the hip straps. Black and prick-stitch four lines on all sides of the openings. Set the buckle in place, and let the broad end of the lay touch on the semicircle of the crupper. Tack the whole down and stitch together, thus forming the crupper body.

Van Harness Crupper. The chief difference between this crupper and that described above is in the dock and the loop equipment. For joining the dock, the body of the crupper is split for 6 in. at the back end. Composed of soft-grained leather, stitched in the shape of a bag, filled with linseed or sawdust, the ends flattened out and the centre rounded and set, the dock is sewn to the crupper. The loops are made in the same way as the loops of the bridle.

Saddle Crupper. Light and slender as it is, the saddle crupper is a very nice piece of work, and strong. Slit the body piece up the centre, about 5 in. at one end, and form the other into a chape for the buckle, narrowing it to the size of the buckle. Sew a strap called a billet over the chape, taking in the buckle; crease, rub, and polish both body and billet. Make a loop and sew it on the body of the crupper, about 5 in. down. Now form the crupper dock with a piece of soft, fine leather. Roll round a bit of thick twine a few plies of brown paper; damp to make it flexible; sew the leather over it, and round it to a circle, with long ends. When fixed and dry, join the ends of the dock to the split ends of the crupper body. Punch holes for the buckle tongue in the overlapping billet; blacken and finish.

Breeching. We have the breeching ready cut—a long piece of leather 7 ft. 4 in. in length. Turn it down to 4 ft. 10 in., in the manner of the turning for buckle chapes; run the trimmer along the edges; blacken; make a double crease along both sides; shave both ends, and race a line across about $1\frac{1}{2}$ in. from the centre of the band. Cut the lining pieces to size; skive the ends, turn over, and put in between the folds of the breech. Stitch down the linings, forming at the same time the eye of the bridgeband pin. Trim, blacken, and beat flat the bend; sew the double parts firmly together.

Put on the lay in the centre of the body, and tack down. Now begin to stitch, sewing long

lines and cross lines, as marked. Cut out the holes for the bridgeband chains and the tugs. Form the bridgebands, with D-rings and screws, and join.

The loin straps and breech tugs are double straps that connect the breech with the crupper. As we have seen, the loin straps run through the crupper from side to side. Having formed the tugs and sewn on the buckles, we stitch them to the breech, thus forming the back harness into a unity. The back harness of vans, gigs, and carriages have special additions, such as the breeching-straps, backband, and shaft tugs; but in no case do they present any difficulty to the man who has made a cart harness.

Horse Collars. The materials and procedure for horse collars are as follows:

In ironmongery we need frames, hame clips, terrets, swivels, and buckles.

In cutting out we have forewale, 4 ft. by 7½ in.; straps, 18 in. by 1½ in.; linings and side pieces to measure and pattern; felt linings also to pattern.

Setting the Forewale. Damp the forewale piece and stretch it firmly by pulling evenly with the pincers all round. Measure off ¼ in. on one side and mark; mark off 2 in. on the other side; fold over, and make the two marks meet the spare ¼ in. on the inside to form the hinge of the lining, the 2 in. of spare on the outside being the hold for the side pieces of the collar. Make a long, strong, and well-waxed thread, and select a fine strong needle. Stitch firmly along the line of the marks, making the leather into a pipe with flanged joints.

Stuffing. Get ready a large bunch of good straw for stuffing, and lay the forewale round the collar block. Having made a straight wisp of straw, thrust it into the forewale with the stuffing rod, driving it home evenly, yet not with such force as to break the straw or cause it to lump. Put a nick at the centre of the forewale, and press the foot a little on the inside to the left of the nick, driving down wisps of stuffing into each side alternately. When near the top, turn the ends in, and beat the stuffing firmly down. The ends of the forewale, if the stuffing be firm, are standing apart. Put a stitch of strong thread through both ends, and pull them together, easing up with the hand iron, till they are close. Join with the stitching so as to make an even top. The forewale is ready for the body of the collar.

Making the Collar Body. Now we are ready to begin making the collar body [13]. The greater part of the lining is a textile fabric, either woollen felt or cloth, or linen; but the bottom part, called the *throat piece*, is nearly always of soft leather, and often the top is basil. We think it best to shape our lining for leather on the bottom only, making the whole inside one fabric. Hem the throat piece to the lining, joining so that the narrow end of the throat piece will lie in to the forewale when the lining is in place. Centre the narrow end of the throat piece on the inner rim of the forewale, and sew it tightly on. Turn in the edges of the lining, tack slackly on the forewale just above the bottom curve; draw up tightly, and make another tack about 5 in. from the head. Make a long four-cord waxed thread, cut it in half, and with one half thread the harness needle. With the help of an awl, whip-stitch the lining on to the outer rim of the forewale, keeping the stitches to the inside.

Stuffing the Collar. Stuffing a collar is exacting work. Place everything required within easy reach. Wax a bit of strong twine 3½ yd. long; make a seven-cord waxed thread 1½ yd.; straighten and select a bundle of good straw; have at hand the throat strap, the hand iron, collar needle, seat awl, collar knife, scissors, and mallet. Sit down; thread the collar needle with the waxed thread; place the collar, throat upwards, against the left knee, with the right leg inside.

Select a big handful of straw; lay it across the centre of the throat piece on the forewale; with needle and thread, stitch from the centre of the throat over the straw to the broad margin on the other side, for about 6 in.; do 6 in. on the other side of the centre in the same way. Drive in straw till the whole bottom is hard, then fix it by buckling the throat belt over it.

Form a wisp of straw the length of the side of the collar, wind it round with hemp to make it firm and neat. Pull out the lining as flat as possible; underlay it with a padding of flock; fill round with straw, then thrust the long packet of straw down the centre, pushing well in on the bottom packing. Lace the lining to the forewale from where the stitching left off, right to the head. Perform the same operation on the other side. Fill up, and then draw the lacing as tight as it will hold. Shape the body of the collar, and where depressions appear, loosen the lacing and put in more packing, making sure that the straw has been pushed well into the seams. Crop the straw even at the top; form a leather cap; join it on the forewale, sew down the lining, and cover the join with the leather cap.

Finishing the Collar. Having already punched, creased, and blacked the collar straps, sew one on each side of the forewale, about 5 in. from the top, putting the stitches into the groove formed by the sides of the collar and forewale at the point of contact.

Collar side pieces are shaped so as to cover the body all round, forming a projecting roof over it. Fit the two pieces on the collar and trim the size at top; join them together by stitching, and strengthen the joint by a binding of leather. Damp the collar cover; clear it of water; set it in place and fix it to the top of the collar body with an awl. Pull the side pieces well down close to the body and begin to lace-stitch, making sure that the lining is caught in with the stitches. Lace-stitch again, this time joining the forewale and side pieces. When done, the collar should be a strong, firm bit of work.

We have gone over the principal points, leaving aside the smaller details, about which nearly every harness-maker has his own pet ideas, based, we suppose, upon local experience.

Van harness collars are made of finer materials; but in structure they differ in no essential particular from cart collars.

Continued

LIGHT & WARMTH IN THE HOUSE

What Colour is. The Value of Sunlight. Artificial Light. Heat Radiation. The Perfect Stove

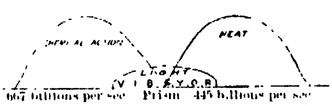
Group 25
HEALTH
18

Continued from page 5056

By Dr. A. T. SCHOFIELD

THE sun is the life, the light and the warmth of the world. Let us turn to the illustration showing the threefold action of the sun's rays [24]. In the centre we get the prism, with its seven colours or notes corresponding to the notes in music, the former being due to vibrations in ether varying from 445 billions per second at the red end to 667 billions per second at the violet end, as compared with those in air producing sound, which vary from 16 per second in the bass to some 30,000 per second.

What we Mean by Colour. Colours are therefore to light as pitch is to sound. Of course, colour is not a property of things but of light. In complete darkness all the ribbons and flowers in a shop are the same colour, or, rather, no colour at all. The apparent colour in various things and substances simply arises from the different part of the prismatic rays they are able to absorb, varying from the extreme of white (paper or linen, etc), which can absorb none of the seven colours, but reflects the whole back to the eye, forming white, to black (paper, ink, etc.), which absorb all and reflect none back. A red rose, therefore, absorbs all the upper end of the spectrum (violet, etc)., and reflects the lower, whereas with a violet it is the reverse; and inasmuch as the red rays are within those vibrations that give heat, we call it a warm colour, while violet and blue are cold.



24. DIAGRAM SHOWING ACTION OF SUNLIGHT

A picture, therefore, may be called a song painted in ether, while a song is a picture painted in air. An instrument has been devised that plays music for the eye instead of the ear in colours.

All light, it is now known, does not come from the sun. Radium and other substances have power to emanate it. Electricity, too, has five times the chemical or metabolising (life-sustaining) power of the sun's rays when presented in the arc light.

As we have said, the violet end of the spectrum and beyond it are life-sustaining and growing rays, the middle or yellow part of the spectrum is the centre of the light rays, and the red end and beyond are the heat rays, so that violet, yellow, and red may be taken to represent the three primary colours.

Glass intercepts the radiant heat rays, but allows the dark, most of the light, and chemical rays to pass through. But though the radiant heat rays cannot pass directly, the light rays may be decomposed in passing through and reflected as heat rays, as in a greenhouse. Glass also intercepts some light rays; polished plate glass stops 13 per cent., ordinary glass 30 per cent., and rolled plate stops 53 per cent.

Sunlight and Health. The hygienic value of sunlight is naturally very great, as it contains such powerful chemical rays. The value of sunbaths is very great. The aspect of houses is also of great importance. Nurseries and all living-rooms should get plenty of sun, as we have seen. Sunlight is a powerful bactericide, as these organisms flourish in gloom and darkness. Some deep Swiss and Derbyshire valleys are so situated that the sun hardly ever penetrates them. Here disease is rife, and goitre flourishes. It is found that barracks which face the sun are much healthier than those with a northern aspect. In England we want every ray of sun that we can get. In hot climates, it should be noted, French windows are not good, as they let in too much light from below.

Artificial Light. A great part of our existence is illumined by substitutes for sunlight of some sort. These consist almost entirely (save in electric arc light) of incandescent carbon or some of the rarer earths.

In the incandescent electric light we have carbon only. In gas and mineral oil we have carbon and hydrogen; in colza oil, carbon and oxygen: in incandescent gas, some of the rarer earths. Hydrogen, when heated, combines with the oxygen in the air to form H_2O (water), and gives a non-luminous flame of great heat. The carbon, which in a lamp is in the oil as well, makes the flame luminous as its particles become incandescent. Carbon and oxygen in air form CO_2, carbonic acid gas, and ignite with a luminous flame.

No colours are fully seen in this or any other artificial light, because only in sunlight do we get the full prismatic colours in their right proportions.

Candles owe their light to the incandescent carbon in the wick and grease. The standard sperm candle burns 120 grains per hour. This represents one-candle power. It burns 80 per cent. of carbon, 13 per cent. of hydrogen, 6 per cent. of oxygen, and produces per hour ·4 cubic ft. of water and ·4 cubic ft. of carbonic acid gas.

One paraffin candle burning 62 grains per hour burns 86 per cent. of carbon and 14 per cent. hydrogen, and produces ·2 cubic ft. water and ·2 cubic ft. carbonic acid gas per hour. One cubic ft. of coal gas, when burnt, produces ·5 cubic ft. carbonic acid gas. Lamps are used with petroleum and colza oil.

In petroleum the flashing point—*i.e.*, the temperature at which inflammable vapour is given off—must not be below 73° F. Explosions are caused by the ignition of the vapour. Sand is

the substance for extinguishing burning petroleum—water is useless. Colza oil gives a soft, gentle light, and is good for the sick-room and for reading.

Lamps burn about 150 grains of oil per hour and produce ·6 cubic feet CO_2. They also burn 62 grains per hour per each candle-power of light they give.

Gas is produced from coal, and is really a combination of marsh gas (CH_4), which gives heat, and olefiant gas (C_2H_4), which gives light, together with some other gaseous hydrocarbon, such as naphthaline.

Gas-light has been enormously improved, owing to the competition of the electric light. The incandescent burner has practically revolutionised the using of gas. The ordinary burners are the fishtail of 16-candle power, the batswing of the same, and the argand of 30-candle power.

The number of candle-power which any gas-light is equal to is ascertained by the shadow of an object illuminated by candle and gas on a white screen. The intensity of light rays (like heat) diminishes with the square of the distance.

Each cubic foot of gas burnt per hour produces about the same amount of carbon dioxide as the respiration of a man. A man produces ·6 cubic ft. of carbon dioxide per hour, and 1 cubic ft. of gas produces ·52 cubic ft.

	Oxygen Used	CO_2	No. of Men equal to
A good flat flame burning 5 cubic ft. per hour and = 16 candles	6·5	2·5	5
Same light with petroleum, and = 16 candles..	6·2	3·5	7·5
16 separate candles ..	9·5	6·5	11

One cubic ft. of pure CO_2 requires 900 ft. of air per hour to dilute it, therefore each flat gas-jet burning 5 cubic ft. per hour requires over 2,000 cubic ft. pure air per hour above what is required for any persons in the room if the air is to be kept fresh.

A ground-glass shade over the light takes away 30 per cent. of the light. Incandescent mantles give as much light as argand burners, and burn little more than an ordinary gas-jet. They can also be used inverted, so as to throw the light down, which is a great advantage. Gas, however, has many disadvantages; it uses up the air, and its products destroy all gilding, books, stones, mortar, and iron.

Apart from the incandescent light, "sunlight" or ordinary gas-fittings fixed to the ceiling, through which they ventilate, are best. Gas should issue from the burner slanting and at low pressure, and there should be a plentiful supply of fresh air to every part of the flame.

Unburnt gas is very dangerous, and with pressure a good deal may escape into the room, containing 6 per cent. of the deadly poison carbonic oxide (CO); hence care is required. Any hissing and flaring is bad. A gas regulator on the meter is invaluable, and generally saves its cost.

The Welsbach incandescent mantle is of asbestos and other rare earths, and can burn with a non-luminous flame. Gas that could be used with such a mantle could be supplied, if the demand were sufficient, at 1s. per 1,000 ft.; very little gas is required, and the light is much whiter—all excellent qualities. The albo-carbon is a very brilliant white light, and is really naphthaline. It is commonly used for motor-lamps. Gas should not be used in nursery bed-rooms, although it is excellent in halls and passages.

The electric light for domestic purposes should always be incandescent. It is a cool and sanitary light, as it gives little heat and consumes no air, being, indeed, only capable of burning in a vacuum.

The substitution of electricity for gas in a large bank has so reduced the sickness as to pay for its instalment. On the other hand, the arc light in another bank had to be taken down and incandescent lamps substituted, owing to the mental excitement and exhaustion its powerful chemical rays produced.

The Production of Heat Rays. We must now turn from the brief summary of light to the kindred topic of heat.

Heat rays are conveyed by radiation, by air, by conduction by solids, and by convection by gases and liquids. They are produced by the combustion of fuel composed of carbon and hydrogen in an atmosphere containing oxygen, the products of combustion being invariably (as for light) carbonic acid (CO_2) and water (H_2O).

Every pound of carbon produces $3\frac{1}{2}$ lb. of CO_2 and can raise 87 lb. of water from 60° F. to 212° F.; in other words, it can produce some 13,000 heat units, a heat unit being 1 lb. raised one degree.

The perfect combustion of 1 lb. of dry wood produces 6,400 heat units.

One pound of peat produces 7,200, of coal 10,000, of petroleum 20,000, of carbon (as we have seen) 13,000, of hydrogen 62,535. This last is remarkable. Every pound of hydrogen will produce by combustion 9 lb. of water, and can raise 417 lb. of water from 60° F. to 212° F., which is equal to 62,500 heat units.

In the evaporation of water intense cold is produced, and this is why such severe chills and pneumonia are contracted even on a hot summer's day by the rapid evaporation from the hot surface of the body, if wool be not worn next the skin. Nine hundred and sixty-six heat units are lost for every pound of water evaporated.

Heat Radiation. Heat radiates in straight lines, but these cannot be seen till the vibrations reach 446 billion waves per second, when they appear as red rays at the slowest end of the spectrum.

Heat radiates through transparent mediums without loss, except through glass, which, if $\frac{1}{2}$ in. thick, absorbs half, only the dark heat rays passing through. A body may be transparent and yet be impervious to heat rays, or it may be opaque and yet allow them to pass. Blue glass is opaque to red and yellow rays, and vice versa.

Convection occurs through currents of air or water, which carry off heat from the body. When a man stands out of doors they stream from him in every direction, and oblige fresh

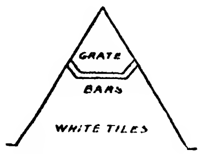
currents of air to flow toward him. Therefore the nearer the outer temperature is to 98° F. (blood heat) the less the circulation of air round the body. When the two are equal, as in India, the air stagnates, and the punkah, or electric fan, is needed.

Smells unfortunately diffuse along warm currents of air also by convection.

Eighty-one pounds of air fill 1,000 cubic ft., and contain a certain amount of moisture, which is deposited if there are solid particles in the air (soot, etc.), forming a fog.

Radiant heat does not warm the air through which it passes, but all solids which it strikes. It therefore prevents the formation of water on walls through condensation by warming them.

The vapour of water absorbs the luminous rays of radiant heat, but not others. Walls and furniture of light colours make a room warmer because they reflect the radiant heat instead of absorbing it.



25. A WELL-BUILT GRATE

With radiant heat in a room, the result is cold air and hot chairs; with warmed air, the result is cold chairs and hot air the ideal is a mixture of the two.

Coal fires yield only 13 per cent. of the heat produced in the room, and wood fires 6 per cent. Radiant heat can keep the temperature of a room 60° to 65° F., adds no impurities, but lets five-eighths of the heat escape up the chimney. In English houses the temperature is not alike in any two places. The hottest place is by the fire in the room, and the further away the colder the room. When the room is opened and the passage entered it is colder still; on the staircase more so; in the hall chilly; and at the hall door quite cold.

In an American house heated with warm air this is not so. One is in the uniform temperature of a mild hot-house everywhere. Bed-room, sitting-room, cupboards, passages, hall, staircases, all are uniform. The result is that one steps much more suddenly out of the heat into the cold, and severe chills are more common, though it is undoubtedly more luxurious and comfortable. Some people, moreover, never get accustomed to breathing warmed air.

The intensity of heat decreases inversely with the square of the distance. Thus, if one stands 3 ft. away from a fire one only gets one-ninth of the heat that would be felt 1 ft. away. At double the distance, 6 ft., instead of getting half (one-eighteenth) one only gets a quarter (one-thirty-sixth).

The open fire is wasteful, but most hygienic. The grate is a powerful ventilator. As a rule there are many faults in its construction: Grates are set too far back; the flue is built too straight; the back and sides are of iron, which absorbs the heat, and there are bars at the bottom, which, further, are too wide apart.

A good grate, like the Grosvenor, is set well forward into the room, has firebrick back and sides, and above slants forward to a narrow flue. It has close bars beneath, with a waste preventor in front stopping all draught from below.

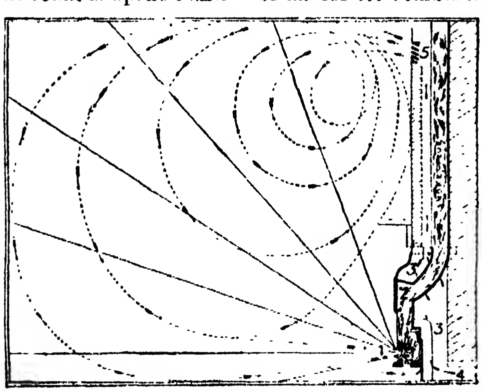
There are also grates with solid floors level with the hearth, sunk floors below it without any bars at all; grates that are fed from beneath; "down draught" grates, where the flue is carried downwards; and grates where the whole fire is contained in a sort of brass coal-scuttle, like the "Nautilus."

In the Teale grates there is a solid floor, back and sides being of firebrick, arched forward to one-third of the front, with a very narrow chimney-throat. The Staffordshire grate is a good one, and consists of an angular recess lined with firebrick or white tiles, and bars across the front [25].

Fireplaces. Fireplaces, when possible, should always be fitted in an inner wall, so that all the heat warms the house. Underfed fires are smokeless, but are much more trouble to work.

An ordinary fireplace burns about 8 lb. of coal per hour, which in a perfect fireplace, with care, can be reduced to 2 lb. It requires 2,400 cubic ft. of air for its combustion, but the up-draught of the heated chimney draws 20,000 more cubic ft. per hour out of the room, thus ensuring a constant rush of fresh air by doors, windows, etc.

The Galton grate [26], which allows air to circulate round it, and warms it, gives double the heat with the same fuel.



26. THE GALTON GRATE, SHOWING RADIATION AND VENTILATION IN ROOM
1. Grate 2. Flue 3. Warm air flue 4. An inlet 5. Warm air outlet

The ideal grate only lets enough heat escape up the chimney to warm it and produce a draught. Of course, the heat that enters the room is principally by the radiation of luminous rays; and it must be remembered that luminous heat rays are more healthy than dark ones.

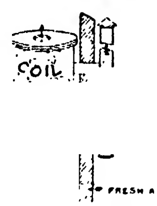
Gas fires, when open and set in a chimney-place, are good, producing no smoke. The fogs may be as frequent in towns where these are common, but they are less yellow. Sulphur fumes are still produced. Water-gas makes the most economical fire, owing to its heat properties. It is produced by a blast of steam over red-hot coke, continued for 14 minutes, when the coke has to be re-heated for 10 minutes by blasts of

air. The resulting gas is purified by oxide of iron, and stored. It has, however, 33 per cent. of CO instead of 6 per cent., as ordinary gas, and as this is a deadly poison its use is dangerous. It gives a superior heat to gas, has no sulphur fumes, produces pure water and CO_2 by combustion, and costs only 4d. instead of 3s. per 1,000 ft. What this could mean to the poor in winter may be imagined. As, however, it is such a powerful respiratory poison, if unburnt, it has never yet become popular.

Stoves. All gas radiation stoves or geysers must have flues to carry the burnt product out of the room. Calorigen stoves are economical [27]. In them a coil full of air from outside passes through the gas fires, so that the room is heated by the warmed air as well as the gas.

Stoves conduct heat from one molecule to another, and also by convection by movement of the heated air. They may be closed, ventilated, or open, and air should freely circulate round them.

The slower the combustion, the greater the heat they give out for the same gas. They are good for warming rooms, but have no ventilating power. They dry the air; there is the same absolute humidity with less relation. A vessel of water should therefore always be placed on the stove to evaporate.



27. AN ECONOMICAL STOVE

If stoves are overheated at 150° F., the organic particles in the air, coming in contact with the heat, begin to char and produce a peculiar close smell. Cast-iron stoves heat too soon and cool too quickly, and also give off CO (carbonic oxide). Stoves with flanges are good. The best are lined with fireclay, while some are made entirely of porcelain.

Heating by hot air is better and cheaper than by hot-water pipes, which always produce draughts. In public buildings, such as churches and halls, no great heat is needed, on account of the warmth given off from the people present. The heat from one man is equal to that from one yard of 4-in. pipe at 200° F. if the temperature is 50° F.; it 70° F., only half as much heat is given off. Women give off half the heat of men.

The heat of a church should be kept at 56° to 58° F. by pipes, and this should be lowered or cut off when it is full. Public buildings generally require 5 ft. of 4-in. iron piping for every 1,000 cubic ft. to raise the air to 55° F. in cold weather. If the pipes are inside the building the best place for them is in the window recesses, not too near the floor. Steam-pipes (1 in. instead of 4 in.) are handier than hot water.

The Ideal Heating System. In a perfect system of supply, the warmed air is filtered, washed, damped, and enters the church or hall 4 ft. above the head in an upward direction. The foul air, with germs, dust, etc., is drawn off at the floor level by a shaft reaching above the roof. The air is changed six to ten times per hour. This removes all fog, and keeps the air pure.

Forced ventilation can be obtained by forcible extraction of air, allowing the fresh air to rush in naturally to supply its place, or forcible impulsion of air, causing the foul air to pass out. Of the two, impulsion is the better. Forced ventilation is much more under control in all weathers than any natural ventilation, which really depends for its efficiency on the difference of temperature within and without.

In the ordinary class-room with natural ventilation only, we get 1,556 bacteria in each cubic foot. In forced ventilation with extraction we get 2,000. In forced impulsion the number is brought down to 198 only. The inlet chamber is made of cement and concrete, and contains pipes for heating the air and a string screen down which water is ever flowing for washing, and a gas-engine 4 to 6 h.p. to pump it in by the fan. It enters above the head. A slow fan and large inlet channels cause least draught. In rooms the air is drawn off at the top, in churches and schools at the bottom by a high shaft, but no exhaust or fire at bottom of shaft is needed with forced impulsion.

The reason why extraction of air is so much less desirable than impulsion is because a vacuum is produced by sucking out the foul air with a fan, and thus fresh air finds its way in anywhere, whatever its state of foulness. The care should really be spent on the fresh air that enters, not on the foul air that leaves. Of course, in no case must entrances and exits be near together. A floor entrance is bad, because it must carry up with it for respiration all the foul dust and dirt of the floors. This is the weak point of the House of Commons ventilation.

Heating by Hot Water. Before leaving the question, it should be noted that all hot-water heating requires special inlets and outlets for ventilation, because there is no open fireplace. A hot-water system or steam at low pressure has 4-in. pipes, with ventilation at the highest point. The circulation is at 200° F. from the boiler. In high pressure there is no boiler. The pipes are 1 in. wrought iron, with a ½-in. bore passing through a furnace, and the heat is 350° F. Perkins' hot-water pipes are a closed circuit coiled for one-sixth of their length in a furnace, with an expansion tube at the highest point, and an inlet just below it. They maintain a temperature of 300° F. Soft water is best for these pipes. Boilers burst through being encrusted, and by frost.

One foot of 4-in. pipe at 200° F. raises 222 cubic ft. of air one degree per minute. To find the length of 4-in. pipe to warm a church, divide the cubic feet of space by 200. This gives the length of pipe in feet. For house warming allow 12 ft. for every 1,000 cubic ft., to maintain 65° in mild, 50° in cold weather. Work-rooms require 6 ft. per every 1,000 cubic ft. to reach 55° F.

Every square foot of glass window cools 1¼ cubic ft. of air per minute, down to the external temperature. Heated air from a central furnace on the American plan can be supplied to rooms or flats at 8d. per 1,000 cub. ft. per annum if by day only.

Continued

CIRCLES

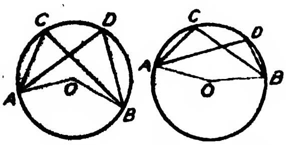
Circles—contd. Angles in Same Segment. Concyclic Points. Quadrilateral in a Circle. Arcs and Chords. Definition of Tangent. Tangent Properties

continued from page 5044

By HERBERT J. ALLPORT, M.A.

Proposition 40. Theorem

Angles in the same segment of a circle are equal.



Let ACB and ADB be angles in the same segment ACDB of a ⊙, whose centre is O.

It is required to prove that $\angle ACB = \angle ADB$.

Proof. Join AO, BO.

Then $\angle AOB =$ twice $\angle ACB$ (*Prop.* 39),
and $\angle AOB =$ twice $\angle ADB$ (*Prop.* 39).

$\therefore \angle ACB = \angle ADB$.

Circle Through Three Given Points.

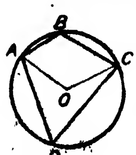
It has been shown that a point can be found which is equidistant from three given points not in the same straight line. Hence, a circle can always be described through these three points. Its centre will be the point equidistant from the three. Again, this point which is equidistant from the others was shown to be at the intersection of a certain pair of straight lines; and, since a straight line cuts another at only one point, it follows that only one circle can be described through three given points.

Only under certain conditions can a circle be drawn through more than three points.

If a circle can be drawn through four or more points, the points are said to be *concyclic.*

When a rectilineal figure can be placed so that its angular points lie on the O^{ce} of a ⊙, it is said to be *inscribed* in the circle: the circle is said to be *circumscribed* about the figure.

Proposition 41. Theorem



The opposite angles of a quadrilateral inscribed in a circle are supplementary.

Let ABCD be a quadrilateral inscribed in the ⊙ whose centre is O.

It is required to prove that

$\angle ABC + \angle ADC = 2$ right $\angle$s,
and $\angle BAD + \angle BCD = 2$ right $\angle$s.

Proof. Join OA, OC.

Then $\angle ABC$ at the O^{ce} = half the reflex $\angle AOC$ at the centre, standing on the same arc ADC, and $\angle ADC$ at the O^{ce} = half the $\angle AOC$ at the centre, standing on the same arc ABC.

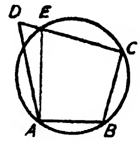
$\therefore \angle ABC + \angle ADC =$ half the sum of the $\angle$s at O = 2 right $\angle$s (*Cor. Prop.* 1).

Similarly it can be shown that

$\angle BAD + \angle BCD = 2$ right $\angle$s.

Proposition 42. Theorem

If two opposite angles of a quadrilateral are supplementary, the vertices of the quadrilateral are concyclic.



Let ABCD be a quadrilateral in which

$\angle B + \angle D = 2$ right $\angle$s.

It is required to prove that A, B, C, D are concyclic.

Proof. Draw the ⊙ through the points A, B, C.

If this ⊙ does not also pass through D, let it cut CD, or CD produced, in E. Join AE.

Then, since ABCE is a quadrilateral in a ⊙

$\therefore \angle B + \angle AEC = 2$ right $\angle$s (*Prop.* 41).
But $\angle B + \angle ADC = 2$ right $\angle$s (*Hyp.*).

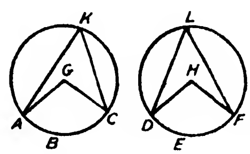
$\therefore \angle AEC = \angle ADC$, which is impossible, since the exterior $\angle$ of the ΔAED must be greater than the interior opposite $\angle$.

$\therefore$ the ⊙ must also pass through D.

Proposition 43. Theorem

In equal circles, if two arcs subtend equal angles either at the centres or at the circumferences, the arcs are equal.

Let ABK, DEL be equal ⊙s, and let $\angle AGC = \angle DHF$, at the centres, and therefore the $\angle AKC = \angle DLF$ at the O^{ces} (*Prop.* 39).



It is required to prove that the arc ABC = the arc DEF.

Proof. Place the ⊙ ABK on the ⊙ DEL so that the centre G falls on the centre H, and GA falls along HD. Then, since $\angle AGC = \angle DHF$, GC will fall along HF. Also, since the ⊙s have equal radii, the points A and C will fall on the points D and F respectively, and the O^{ces} of the two ⊙s will coincide entirely.

$\therefore$ the arc ABC = the arc DEF.

Proposition 44. Theorem

In equal circles, angles, whether at the centres or the circumferences, which stand on equal arcs are equal.

Let ABK, DEL be equal ⊙s [see figure to *Prop.* 43] and let the arc ABC = the arc DEF.

It is required to prove that the

$\angle AGC = \angle DHF$
and that $\angle AKC = \angle DLF$.

Proof. Place the ⊙ ABK on the ⊙ DEL so that the centre G falls on the centre H, and GA falls along HD. Then, since the ⊙s have equal radii, A will fall on D, and the ⊙s will coincide entirely.

$\therefore$ since the arc ABC = $\angle$DEF, the point C will fall on F.

$\therefore \angle AGC = \angle DHF$.

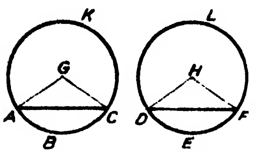
And, since the $\angle$s at K and L are the halves of these (*Prop.* 39),

$\therefore \angle AKC = \angle DLF.$

Proposition 45. Theorem

In equal circles, arcs which are cut off by equal chords are equal.

Let ABK and DEL be equal $\odot$s whose centres are G, H, and let the chord AC = the chord DF.



It is required to prove that the arc ABC = the arc DEF.

Proof. Join GA, GC, HD, HF.

Then the Δs AGC, DHF have the sides of the one equal respectively to the sides of the other.

$\therefore \angle AGC = \angle DHF$ (*Prop.* 7).

$\therefore$ arc ABC = arc DEF (*Prop.* 43).

Proposition 46. Theorem

In equal circles, chords which cut off equal arcs are equal.

Let ABK, DEL be equal $\odot$s [see figure to *Prop.* 45] whose centres are G, H, and let the arc ABC = the arc DEF.

It is required to prove that the chord AC = the chord DF.

Proof. Since the arc ABC = the arc DEF,

$\therefore \angle AGC = \angle DHF$ (*Prop.* 44)

$\therefore$ Δs AGC, DHF, have two sides and the contained $\angle$ of one equal to two sides and the contained $\angle$ of the other,

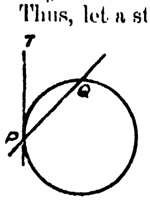
$\therefore$ AC = DF (*Prop.* 4).

NOTE. The properties proved for *equal* circles will evidently be true in the case of the *same* circle.

Tangent Properties

Tangent. A straight line cuts a circle in two points. If the line moves in such a way that the points approach one another and ultimately coincide, the straight line then becomes a *tangent to the circle*.

Thus, let a straight line cut a $\odot$ in the points P, Q. Imagine P to remain fixed, and Q to move along the $\bigcirc^{ce}$ towards P. The line PQ will turn about P, and when Q coincides with P will have come into the position PT. The straight line PT is the tangent to the $\odot$ at P.



Contact of Circles. If two $\odot$s cut one another at P and Q, and we imagine Q to move up to, and coincide with, P, then the $\odot$s are said to *touch* at P, and the straight line PQ becomes the tangent to both $\odot$s, at P.

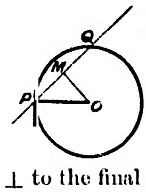
Proposition 47. Theorem

The tangent to a circle at any point is perpendicular to the radius drawn to that point.

Let P be any point on a $\odot$ whose centre is O.

It is required to prove that OP is $\perp$ to the tangent at P.

Proof. Let PQ be any straight line through P, cutting the $\bigcirc^{ce}$ again at Q. Draw OM $\perp$ to PQ. Then OM bisects PQ (*Prop.* 36). Now let Q move along the $\bigcirc^{ce}$ till it coincides with P, and let PT be the final position of the straight line. Then PT is the tangent at P. Also, when Q coincides with P, the point M (which is always midway between P and Q) must also coincide with P, *i.e.*, OM coincides with OP. And, since OM is always $\perp$ to PQ, its final position will be $\perp$ to the final position of PQ.



$\therefore$ OP is $\perp$ to PT.

Corollary 1. Since only one line can be drawn $\perp$ to OP at the point P, *one, and only one tangent can be drawn to a circle at a given point on the circumference.*

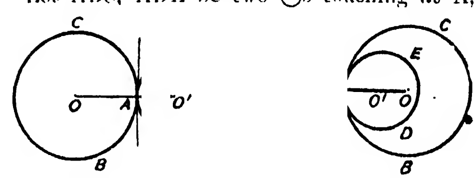
Corollary 2. Since only one line can be drawn $\perp$ to PT from the point P, *the perpendicular to a tangent at its point of contact passes through the centre.*

Corollary 3. Since there is only one line from O $\perp$ to PT *the line drawn from the centre perpendicular to a tangent passes through the point of contact.*

Proposition 48. Theorem

If two circles touch, the straight line joining their centres passes through the point of contact.

Let ABC, ADE be two $\odot$s touching at A,



and let O, O′ be their centres.

It is required to prove that OO′ passes through A.

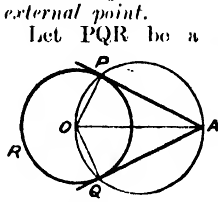
Proof. Since the $\odot$s touch at A, they have a common tangent at A. Also, OA and O′A are each perpendicular to this tangent (*Prop.* 47)

$\therefore$ A, O, and O′ must be in the same straight line.

Proposition 49. Theorem

Two tangents can be drawn to a circle from an external point.

Let PQR be a $\odot$ whose centre is O, and let A be a point outside it.



On AO as diameter describe a $\odot$ APOQ, cutting the given $\odot$ at P and Q. Join AP, AQ, OP, OQ.

Then, since $\angle$s APO, AQO are angles in a semicircle,

$\therefore$ they are right $\angle$s (*Prop.* 39 *Cor.*), *i.e.*, AP and AQ are $\perp$ to radii.

$\therefore$ they are tangents.

Corollary. The two tangents are equal, and subtend equal angles at the centre. For it is easily seen (*Prop.* 20) that the Δs APO, AQO are equal in all respects.

$\therefore$ AP = AQ, and $\angle AOP = \angle AOQ$.

Continued

THE MANUFACTURE OF RUBBER

Commercial Notes. Making Crude Rubber into Sheets. Making Rubber Goods. Various Processes of Vulcanising Rubber. The Machinery Used

continued from page 5049

RAW RUBBER comes on the market in a variety of shapes and under numberless designations, such as balls, buttons, biscuits, cakes, lumps, marbles, negroheads, niggers, scraps, sheets, spindles, and thimbles, to which the name of the port from which it is shipped, or the district from which it originates, is frequently attached. These names are constantly changing as old ones disappear and new ones are invented.

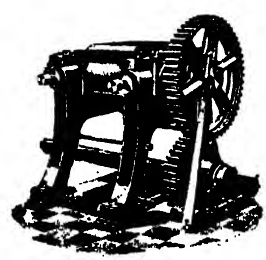
The total production of rubber from all sources has been calculated for the year ending June, 1906, at 68,000 tons; of this quantity, 36,000 tons are estimated to be of South American origin, mostly Brazilian. The next largest source is Africa, with about 23,000 tons. Liverpool is the central European market for raw rubber, but Hamburg is rapidly growing in importance as a trading centre for this product.

The price naturally fluctuates according to the supply and demand, the highest figure which has been attained during recent years was in 1905, when cultivated Para reached the figure of 6s. 9d. per lb., and fine Para 5s. 9d. per lb. Prices since then have fallen somewhat, being now about 5s. 6d. per lb. for the former, and slightly over 5s. per lb. for the latter.

Physical Properties of Crude Rubber. The physical properties of raw caoutchouc may be briefly summarised as follows. It has a distinctive odour, and when it has not been cured by smoking the smell is frequently very disagreeable, especially in inferior brands or qualities. It is very elastic under normal conditions, but when cooled to freezing point, it becomes hard and brittle, regaining its original state on being warmed. When freshly cut, the surfaces are very adhesive and can be easily made to reunite. It is a non-conductor of electricity. Raw caoutchouc is insoluble in water, but has the curious property of taking up nearly 25 per cent. when soaked for a considerable time; its other characteristics, such as extensibility, resilience, and tenacity, are thereby greatly impaired. It is affected in a very similar way by alcohol, but the action is rather more marked. Acetone also has a like effect, and ether causes it to swell considerably, but does not dissolve it. It is soluble in turpentine, petroleum spirit, carbon bisulphide, benzol, and chloroform. Strong acids, such as concentrated sulphuric and nitric acids, attack it vigorously, hydrochloric acid in rather a less degree, and organic acids merely make it swell slightly. Solutions of alkalis have little effect upon crude rubber unless it is heated. Exposure to air and light in a warm place slowly oxidise the rubber on the surface, impairing its elasticity. It begins to melt at about 360 F., first becoming very sticky, and finally liquefies at about 400 F.

First Stages of Manufacture. The crude rubber as received by the manufacturer has first to undergo a preliminary treatment for the removal of impurities, which consists of soaking and surface washing, cutting up, rolling, washing a second time, and finally drying. The first washing has the effect of softening the rubber, which becomes hard on storing, and consists of soaking the rubber for periods varying from two to four hours in hot water. When it is softened sufficiently it is cut into 1½ in. to 2½ in. squares, but if the crude rubber is in small fragments, this naturally can be omitted. The next operation of rolling and washing is a very important one.

The Rolling and Washing Mill. The mill [7] used consists of two heavy horizontal rollers, placed side by side, and supported in a strong frame, which revolve inwardly at different rates of speed. These rollers are either smooth or grooved. A perforated pipe is fixed about 2 ft. immediately above these rollers, so that a stream of water can be directed upon the rubber while it is passing between them. The object of this operation is to remove vegetable impurities, sand, and other mineral matter, and also any acid, alkali, or other chemical reagent which has been used in coagulating the latex. The rollers have a tearing and kneading action upon the rubber, and at the same time crush any solid impurities present, so that they are more readily carried away by the stream of water. Fine Para rubbers and similar qualities are easy to wash, but rubbers of a greasy or pitchlike nature are very difficult to clean properly. After having passed through the rollers several times, the washed rubber issues in a sheet somewhat resembling blotting paper, with a characteristic shrivelled appearance; very dry rubbers, however, come out of the mill in small fragments. Cultivated rubber is frequently washed before coming on to the market, when it is known as *crepe*, or *sheet rubber*.



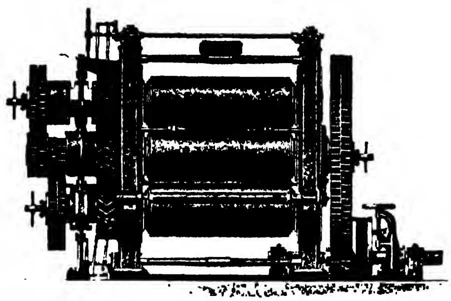
7. WASHING MILL

The crude rubber is fed into the machine by hand, and as this is a somewhat dangerous occupation, an ingenious device has been invented by F. Clouth, whereby, in the event of a workman being caught by one, or even both hands, between the rollers, he can immediately stop the machine.

Drying. The rubber is now dried by hanging the sheets or leaves on poles or iron wires, either in the open or in drying-rooms which are artificially heated and provided with fans for removing the moist air. If the rubber be in small lumps, it is dried on frames. A good supply of fresh air accelerates drying, which in summer takes two or three days, and in winter somewhat longer. The use of vacuum drying chambers has recently been introduced for drying washed rubber. The idea formerly existed that a long period was necessary to properly dry the rubber and to produce a fine nervy product, but it is now recognised that long drying tends to oxidation. When dry, the rubber is rolled up and stored in a dark place until required.

The loss of weight in washing fluctuates very considerably with different qualities of rubber; inferior brands will even lose as much as 60 per cent.

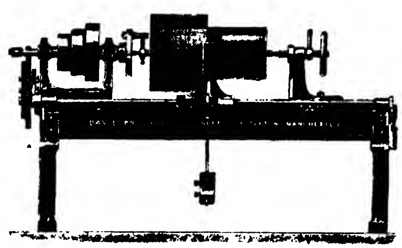
of their weight, but the better qualities rarely lose more than 15 per cent. to 20 per cent. Another factor which has an important bearing upon the value of rubber is the amount of resin that it contains. Fine Para has from 0·6 per cent. to 3 per cent., negroheads generally about 1·5 per cent., Mangabeira contains about 8·5 per cent., other American rubbers 2·5 per cent. to 7·5 per cent. African rubbers seldom fall below 3 per cent., and more usually reach 10 per cent. or 11 per cent., and sometimes as much as 30 per cent. of resin. Asiatic rubbers range from 5 per cent. to 10 per cent., with the exception of Ceylon Para, which contains from 1·5 per cent. to 1·8 per cent.



8. SHEET AND BELTING CALENDER

The Manufacture of Rubber Sheets. The next stage in the process of manufacture is the milling, or mastication, of the dried rubber, in order to reduce it to a soft homogeneous mass. This is done on hot rollers in a machine of similar construction to that used for the washing process. If desired, various ingredients can also be incorporated with the rubber at the same time. Up to this point the treatment of all crude rubber is the same. For articles in which the very best rubber is required, the dried material is only kneaded on the hot rollers, no ingredients being added. When homogeneous, it leaves the mill in the form of rolls, which are compressed into blocks in a hydraulic press. These blocks are exposed to changes of temperature for some months, and are thoroughly frozen at least once. Eventually they are cut up by rapidly moving knife-blades into thin sheets, which are known in the trade as *fine-cut* sheets. These sheets are also produced by pressing the rubber in a cylinder by means of a piston, and from the cylindrical blocks thus formed sheets are cut off in the same way. A very perfect imitation of fine-cut sheets is manufactured by carefully rolling thin Para rubber into sheets between hot rollers, which are engraved so as to produce lines similar to those made by the knives. The resemblance is excellent, but the quality cannot be compared with that of the real article.

By the addition of pigments coloured sheets of various shades can be produced, but the natural colour is generally preferred. In thickness the sheets range from one-sixth to one-fortieth of an inch, and after having been cut they are rubbed with warm soap and water to prevent them sticking together. Up to recent years fine-cut sheets were above suspicion, but now, unfortunately, they are met with considerably adulterated. Fine-cut sheets are used for the manufacture of small objects, such as tubes, bracelets, rings, balls, surgical appliances and air cushions. The procedure is comparatively simple: the desired shape is cut or stamped out of the sheets, the edges which are required to be united are pressed together, when they adhere; the join is then brushed over with benzol, and tapped with a small round-headed hammer. The articles are then ready for vulcanisation.



9. THREAD, TAPE AND WASHER-CUTTING MACHINE

Kneading and Calendering Processes. Additions on the kneading rollers comprise a variety of substances. Sulphur for effecting vulcanisation and various compounds for assisting vulcanisation are incorporated in this way, as well as many other ingredients, according to the special properties it is required to impart to the rubber. Those most largely employed are litharge, zinc white, lithopone, white lead and other lead compounds, sulphide of antimony, chalk, barytes, gypsum, magnesia, metal, soot, asbestos, ground hemp, etc. Many of these are merely added to cheapen the quality, and deterioration in the value of manufactured rubber may be traced, on the one hand, to the consumer's ignorance and inability to judge the quality, and, on the other hand, to over-production, entailing reduced prices, which naturally leads to cheap goods of low quality.

The process of mixing the ingredients with the rubber is as follows: The quantities are first weighed out, and placed between the rollers in small portions: the mass speedily becomes plastic and forms a loose cover round the first rollers, the whole batch finally accumulating in this way on the roller. It is ripped off with a knife after passing through several times, rolled up and again placed in the mill; this is repeated until the whole is uniformly kneaded, when the material is rolled into thin sheets on a calender [8]. The calenders have three, four, or sometimes even six rollers, which are generally hollow and heated by steam. Sheets of various thicknesses may be produced by altering the positions of the rollers, but they are usually about one-twenty-fifth to one-twelfth of an inch thick. The temperature of these rollers is important, and in order that they may be cooled if desired, they are provided with a cold-water pipe which enters at the axle. The rubber leaves the calender on a horizontally-stretched cloth and is rolled on wooden cylinders. To produce the above mentioned imitation cutting marks on rubber sheets the lowest roller is engraved accordingly, or other signs can be imprinted on the sheets in the same way. Rubber in the form of sheets, either cut, rolled, pure or mixed, forms the basis for the production of all kinds of rubber articles, with the exception of waterproof cloth, on account of the ease with which it can be manipulated in this form.

The Preparation of Mechanical Rubber Goods. Small articles are made, as already described in the case of fine-cut sheets, of pure rubber. Mixed sheets are employed for the manufacture of a large number of more bulky objects, such as cords, hose, belting, valves,

roller covers, etc. In many of these an insertion of cotton or linen fabric or woven wire is made.

Discs and flat rings are cut out of sheets by rotating knives [9]; rings are also cut from tubes. Plain cords without any insertion can be rolled out of fine-cut sheets, or made by forcing the prepared material through an orifice of the desired dimensions. In the latter method a variety of shapes can be produced according to the form of the opening. By introducing a core into the orifice, tubes are made in a similar manner. Many goods of a larger description, such as thick discs, valves, billiard cushions, mats and buffers are manufactured in moulds. The material is first cut to shape, and then placed in the mould, where it is vulcanised under pressure. Similarly, hollow articles, pouches, toys, dolls, and so forth, are first roughly fashioned, and then a little liquid is injected before closing up the last join, so that when vulcanised in the moulds the heat develops steam, which forces the rubber into all interstices.

10. SPREADING MACHINE

Insertions of cotton or linen fabrics must be coated with rubber before they can be utilised: this is effected either by passing the tightly-stretched fabric through a calender, which gives it a thin layer of rubber [10], or a solution of rubber in benzine is brushed on by hand. The calender is also employed for producing sheets that are required to have insertions or stiffeners. The rollers are set so as to permit a certain thickness of the fabric and rubber to pass, and for each layer of rubber added the material has to pass once through the calender.

The Making of Cycle and Motor Tyres. For making tubes, hose, or piping, sheet rubber is cut into narrow strips which are wound round a metal tube together with the insertion if such be required [11]. In this way also wire is often introduced spirally between the insertion and the rubber. The vulcanisation of such tubing is generally carried out without removing the metal tube, the rubber being kept in position during the process by a firm binding with linen strips which leave their impression upon the surface. Driving belts are composed of layers, according to the thickness required, of good strong cotton material as insertion. Strips are sewn together longitudinally and encased in a rubber coating: they are then ready to be pressed in the mould. Covers for cycle tyres are constructed in two ways: they are either built up on a drum from strips of sheet rubber, or the prepared rubber is pressed into moulds. Covers for auto-car tyres are made in special moulds. Roller covers are manufactured from thin sheets on a spindle in the same way as tubes, or if made on the axle the rubber sheets are wound thereon and pressed into a uniform cover.

11. HOSE PIPE AND PACKING MAKING MACHINE

Waterproof Fabrics. The material known as *waterproof fabric* finds extensive use for a large number of purposes, such as diving dresses, tents, cushions, mattresses, and beds, as well as for garments; it is manufactured by brushing a solution of rubber in turpentine oil or benzene over the textile fabric by means of a specially constructed machine called the *spreader.* The rubber coating is applied to either one or both sides of the cloth, and "double textures" are made with two layers of material cemented together by the coating of rubber. The machine in which this process is carried out consists of a roller over which a blunt blade is fixed, and immediately behind the roller is situated an iron table heated with hollow plates. The rubber solution is applied to the material just before it reaches the knife or "doctor," which is adjusted according to the thickness of the coating required. On passing the material over the roller the knife removes excess of rubber solution, and while travelling over the hot plates, most of the solvent is evaporated. The process is repeated until a coating of the desired thickness is obtained. Latex fresh from the tree has been tried for coating fabrics in this way but without satisfactory results. After vulcanising, the waterproof material is made up into garments in the same way as other fabrics, except that the seams are solutioned together as well as sewn.

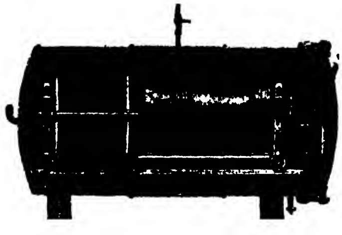
Rubber Shoes and Goloshes. The manufacture of rubber shoes is in itself quite a branch of the rubber industry, and has attained a high state of perfection. The actual process of manufacture comprises uniting the various parts cut to pattern over an iron frame. A special varnish is then applied by brush to produce a fine black gloss, and the shoe is vulcanised on the mould or last. The machinery for rapid production of rubber shoes in quantity is very complicated, the various parts of the shoe necessitating different appliances. Thus, the soles and upper parts require separate calenders, with specially engraved rollers; there are also cutting machines for individual parts, and presses for the heels. The shoes are vulcanised many hundreds at a time, and this process requires great attention and considerable experience, as a fine black, glossy appearance as well as the production of a reliable article depends upon this process being efficiently carried out.

Rubber threads for elastic textures are cut from specially prepared rubber sheets; they are also made of unvulcanised rubber, which is practically the only way in which rubber is now used in the raw state and this to only a slight extent.

A large variety of rubber articles are moulded, necessitating a great number of moulds, in which they are vulcanised under pressure. The moulds, in fact, form a very considerable part of the cost in the production of these goods. Insulated wire is made either by forcing the rubber over the wire by a tubing machine, or strips of rubber are welded together by being run through grooved rollers.

Vulcanising Processes. The next process in the manufacture of rubber goods—*vulcanisation*—is a most important one. The caoutchouc is converted thereby from a more or

less adhesive plastic material, liable to become sticky or pitchy on continued exposure to the air and light, and very sensitive to slight changes from the normal temperature, into a tough, elastic, resilient product, uninfluenced by considerable variations of temperature, and possessing greater capacity for resisting the action of chemical reagents than pure rubber. Vulcanisation was discovered by Goodyear in 1839, but Hancock also independently discovered, after patient research, the vulcanising effect of the prolonged action of sulphur; as however he had already seen samples of vulcanised rubber produced by Goodyear, priority must be accredited to the latter. Goodyear's process consists of mixing sulphur with the raw rubber and subjecting the mixture to the action of heat. Sulphur has no effect on caoutchouc when cold, but if heated to a temperature slightly above the melting point of sulphur—namely, from 265 to 285° F, after about thirty or forty minutes an alteration in the appearance of the rubber takes place and it assumes a yellowish tint. On completion of the treatment it will no longer amalgamate with itself and its elasticity is considerably increased, remaining permanent when cold. Following upon Goodyear's patent for the vulcanisation of rubber with sulphur, a large number of other compounds were suggested by different inventors to take its place. Thus, experiments were carried out with chlorides, iodides, bromides, nitrates, and nitrites, none of which, however, gave results equal to sulphur. Patents were also taken out for vulcanising with bromine, and iodine and sulphur combined, but with inferior results to those obtained with sulphur.



12. VULCANISING PAN, WITH CLOTH CYLINDER

Hancock's Process. By Hancock's process, known as *heat vulcanisation*, the goods are steeped in a bath of molten sulphur at a temperature of 266 to 275° F. for two or three hours, a preliminary drying being essential to prevent seams that have been solutioned from coming apart. Small pieces of rubber are immersed in the bath at the same time, and are taken out from time to time to ascertain how vulcanisation is proceeding. Sulphur is at first absorbed, the rubber turns brown and then orange, and after saturation the real reaction starts which is complete in two or three hours. Immediately after vulcanisation the goods are washed in cold water and the sulphur on the surface removed by scrapers. Goods treated by this method have the defect of "blooming"—that is, sulphur appears on the surface as a grey powder; but it is removable by a treatment with a dilute solution of soda. Small articles made from fine-cut sheets are vulcanised in this way as it is most suitable for them.

Cold Vulcanisation. A third method of vulcanisation is the *cold cure*, invented in 1846 by Parkes, who found that chloride of sulphur also vulcanises rubber, and recommended the use of a mixture of 100 parts of carbon bisulphide and 2½ parts of chloride of sulphur. The articles are dipped in this solution for periods varying from 1½ to 3 minutes, according to the thickness of the articles, then taken out and washed in water, and finally dried. This method can only be employed for thin goods, as long exposure to the action of chloride of sulphur, in order that it may penetrate to the interior parts, causes the outer portions to become *burnt* or over-vulcanised. This process finds favour on account of its quickness, the ease with which it can be carried out, and further, it does not necessitate extensive plant; but, with proper management, the Hancock method is to be preferred.

Other Methods of Vulcanisation. Sulphides of the alkaline methods have also been proposed for vulcanising caoutchouc, and produce a soft, velvety surface, but the method is only suitable for small articles. This is known as Gérard's process, and consists, for instance, in heating the rubber in a solution of potassium sulphide of 25° B., vulcanisation being effected thereby at a comparatively low temperature. Vulcanisation by the vapour of chloride of sulphur, or the *vapour cure*, is another variation for thin goods, but it is seldom employed now. Vulcanisation by sodium, or calcium hypochlorite, or by hypochlorous acid was, at one time, in more common use than now. Since it entails the use of an aqueous solution, vulcanisation by this method is only suitable for very thin goods, or for the production of "surfacings" or "enamels" on ordinary rubber goods, and its use is practically confined to the latter purpose.

Compounding Rubber. The vulcanising process invented by Goodyear finds the most extensive use. A thorough mixing of the washed and dried crude rubber with the sulphur is essential—7 to 10 per cent. being the usual quantity, but even as low as 2½ to 3 per cent. has been met with, and 6 per cent. gives good results. The amount of sulphur actually fixed by the rubber rarely exceeds 3 per cent. After the goods have been given their shape they are placed in a sealed boiler [12] and steamed at a pressure of 3½ to 4 atmospheres for three to four hours, termed the *steam cure*, or, according to the nature of the articles, they are pressed between hot plates.

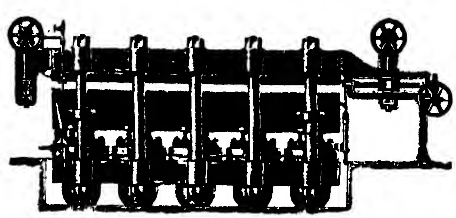
On stretching and pressing goods vulcanised by this method the sulphur blooms on the surface, as in Hancock's process, and can be removed by washing with a solution of soda.

There are several inorganic compounds which play an important part in assisting vulcanisation and in modifying the resulting product. A certain class are known as *sulphur carriers*, the most important of these being sulphide of antimony and the three sulphides of arsenic. In a lesser degree certain lead compounds, such as lead thio-sulphates — technically termed *Hypo* — and litharge, zinc sulphide, and lithopone—a combination of zinc sulphide and barium sulphate. These compounds are employed to assist vulcanisation and to act as a preventive against over-vulcanisation. The exact nature of their action is not thoroughly understood; they enable the manufacturer, however, to reduce the amount of sulphur and to moderate the temperature and length of vulcanisation. In fact, nearly all rubber goods that have not of necessity to be of a white or drab colour contain a proportion of one of these compounds; litharge possibly is the one that is most extensively employed. The well-known red colour of rubber goods is due to the use of antimony penta-sulphide, or *Golden Sulphide* as it is known in the trade. It varies in colour from a reddish orange to a purplish scarlet. English manufacturers, however, generally prefer an

intermediate shade of colour. It is an excellent compounding material, producing vulcanised rubber of fine colour, texture, and durability with little bloom, and is chiefly used for high-priced goods.

Besides these sulphur carriers a large number of other inorganic substances added to sulphur compounds are incorporated in rubber partly for the purpose of increasing bulk, and also for imparting certain characteristics. Others, of the nature of pigments, are introduced for producing certain desired colours. Among those of the former class may be mentioned barytes, or *blanc fixe*, which is employed as a make-weight; it also increases the resiliency of the rubber. Chalk or whiting is one of the inorganic compounds most extensively used for this purpose: in small quantities it increases the resiliency, but also has the tendency to harden the rubber. Lime is sometimes employed, but excess should be avoided, as it induces oxidation, and furthermore reduces the resiliency of india-rubber while increasing its hardness. Magnesia used in moderation increases the toughness and resiliency to a marked degree; it is also used for compounding rubber for insulating wires. On account of its low conductivity of heat, asbestos is largely employed in the manufacture of steam packings. The chief pigments employed in rubber manufacture are white lead, zinc-white, lithopone, golden sulphide of antimony, oxide of iron, cadmium yellow, chrome oxide green, and ultramarine. For black goods lead sulphide is used, but when lead compounds are prohibited, as is often the case for surgical appliances, lampblack must be substituted.

The Addition of Sulphur to the Latex. It is most important that the prepared caoutchouc and sulphur for vulcanisation, or other compounding ingredients, should be mixed as intimately as possible, to ensure good results; but, on the other hand, too prolonged working on the rollers is detrimental to the elasticity and resiliency of the rubber—it becomes *fatigued*; or if the mastication has been carried to such an extent as to render the rubber plastic, it is termed *killed*. With the object, therefore, of securing thorough intermixture of the sulphur and rubber, experimental trials have recently been made of adding the sulphur in definite quantities, about 2 per cent., to the latex before coagulating, so that the crude material is evenly permeated throughout with sulphur, and thus the incorporation of sulphur on the rollers is avoided, as well as the washing operations. It remains to be seen, however, whether this idea will germinate into a practical working method.



13. HYDRAULIC BELT VULCANISING PRESS

The precise nature of the reaction which takes place during vulcanisation of rubber is not yet known. The time and temperature for different goods undergoing the process must be determined by experience, and varies with the size and construction of the goods. Over-vulcanisation, or burning, is caused by too high a temperature; the goods become brittle, and lose their elasticity. Under-vulcanisation is equally bad, and results from too low a temperature, the rubber then retaining to a certain extent its plastic nature. These two defects are especially objectionable, as they are not often revealed until the article is in use. The duration of the vulcanisation process is another consideration, dependent upon the quality of the rubber as well as upon the size of the articles, since some kinds vulcanise quicker than others. Resinous rubbers vulcanise quicker than fine Para caoutchouc.

Vulcanising Machinery. Vulcanising boilers and presses, heated by direct steam, have now largely superseded the walled-in vulcanisation chambers, although these are still in use for rubber shoes and some sorts of rubber cloths, vulcanisation being effected by heating the enclosed air. Steam-jacketed vulcanising boilers also act in the same way. It is curious, however, that a certain amount of litharge is essential to produce satisfactory results with this *dry heat cure*. The dimensions of vulcanising boilers depend upon the size and shape of the articles to be treated, and range from 20 ft. in diameter, and from about 7 ft. to 100 ft., or even more, in length. Rubber hose, being vulcanised on the metal on which it is fashioned, necessarily requires long boilers. The average length of rubber hose in England is about 60 ft., and in Germany often as long as 110 ft. Vulcanising boilers are made of riveted iron plates, similar to steam boilers, and are provided with a steam supply pipe, an outlet pipe for the removal of steam and condensed water at the end of the process, and also means for running off condensed water as it is formed. The pressure is regulated by a manometer, and a safety valve is also fitted. The end of the boiler is closed by a detachable cover carried by a small crane. Movable bolts are attached to the flanged edge of the boiler, and when the cover is brought into position they fall into corresponding notches cut in its edge, and are tightened up by means of nuts; packing is inserted between the boiler and the cover to make an airtight joint.

In order that articles which are not enclosed in moulds shall retain their shape under the influence of heat during vulcanisation in these boilers, they are embedded in French talc, or wrapped in cloths.

Vulcanising Presses for Flat Goods. Vulcanising presses are used chiefly for flat goods, such as mats, driving belts, and heavier rubber goods used for engineering and industrial purposes. Some articles, like driving belts, are vulcanised simply between the plates of the press; others are enclosed in moulds, and are then placed in the press. The most simple form of vulcanising press somewhat resembles an ordinary letter-copying press; the plates, however, are hollow, and are heated by steam. Small presses only a few feet in diameter can be worked by hand, but power is needed for larger presses ranging from 10 ft. to 14 ft. long and 3 ft. to 5 ft. wide. The upper plate is carried by supporting pillars connected at the top by a yoke, through which a worm screw passes for raising and lowering the plate. Hydraulic presses are chiefly employed for the production of heavy driving-belts, and are huge constructions, having two or more cast-iron plates, often 30 ft. long, which are heated by steam [13]. The upper plate is carried between a double row of pillars, and a pressure of 150 atmospheres can be exerted.

The machines shown in this article are from the catalogue of Messrs. D. Bridge & Co., Castleton.

Continued

continued from page 5009

MILLING & GRINDING MACHINES

Milling Machines for Plain and Special Work. Miscellaneous Machines. Plain and Universal Grinders. Various Appliances

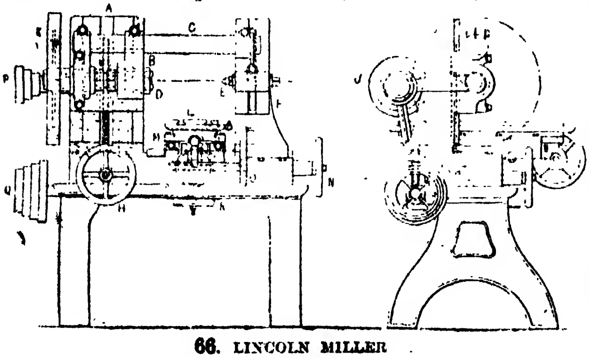
By FRED HORNER

MILLING machines have one thing in common with drilling and boring machines—the use of a revolving spindle. The action, however, is not similar, since in drilling or boring the feed motion is in the longitudinal direction, while in milling the feed motion takes place transversely to the spindle, so that a cutter held in the latter tools across faces either plane or curved. A reference to the article on page 3401 dealing with practice will give an idea of how many different ways milling cutters are applied. And the machines for utilising these cutters assume diverse forms, with spindles both vertical and horizontal, or capable of angular settings. As in some other types of machine tools, it may be either the cutter or the work that moves, but in the majority of cases a table carries the piece past the cutter revolving in fixed bearings, this being more convenient from some points of view than travelling the cutter. It is necessary to have a frame or housing to support the bearings of the spindle, but, if fixed, this frame is of lighter and simpler construction than if it had to travel on ways, and by being fixed it lends itself to certain adjustments and fixings of auxiliary portions readily. The feeds of milling machines are continuous, and not intermittent, like those of the reciprocating machines, because there is no to-and-fro cut and return stroke. The time wasted in these strokes is saved by milling, this being one of the many advantages of the process.

Early Machines. Although milling as a method of tooling is not new, its development has only proceeded rapidly in the last twelve to fifteen years; many factories producing special objects, such as guns, sewing machines, etc., have employed milling machines extensively before their use became general in ordinary engineers' shops. The machines in these special shops are very light in character, and they do not attempt heavy tooling. Hence, though milling has been found an excellent method in such work, when it was first applied to heavy objects, which had hitherto been done on the planer and allied machines, difficulties were experienced in getting such good results as by planing with narrow-pointed tools. The reason lay principally in not making the machines stiff enough, and the spindles strong enough, to withstand the great strain of cutting. The weak portions therefore *gave* or sprung slightly, and the cutters were consequently not held up to their work as they should be, resulting in uneven surfaces and the production of innumerable chatter marks over the surfaces. The cutters were also partly to blame in not being ground with the teeth truly concentric, so that all the work perhaps came upon a few teeth only, and they were unable to stand the feed put on. Improvements have been made in the way of using stiffer spindles, adequately supported in bearings close to the cutters, by giving ample bearing surfaces, and by putting plenty of metal in slides and saddles to absorb vibration where a light flimsy casting would be too weak. Provision for taking up slackness in bearings or slides is also important, because any shake or looseness is fatal to the accurate working of cutters.

The lathe was the first machine in which milling was done, by holding a cutter in the spindle and traversing the slide-rest, holding a piece of metal, across in front of it. Plain faces and slots were milled in this manner. The first true milling machine still retained the lathe features, comprising simply a head, with cone pulley and spindle, and a sliding rest lying below the cutter. The extent to which this broad principle is still carried out may be seen from the illustrations of machines in this article. There were two features in the bald design that were quickly modified, one being the addition of a height adjustment to the spindle to accommodate work of different depths, and a cross motion to the table to bring work nearer to or farther from the cutter. With the addition of a self-acting feed instead of a motion by handle, and a gear drive in place of the plain belt cone, we have what is termed a *Lincoln miller*, used to an enormous extent in shops doing repetition work, of either plane or curved outlines, the use of gang mills being common.

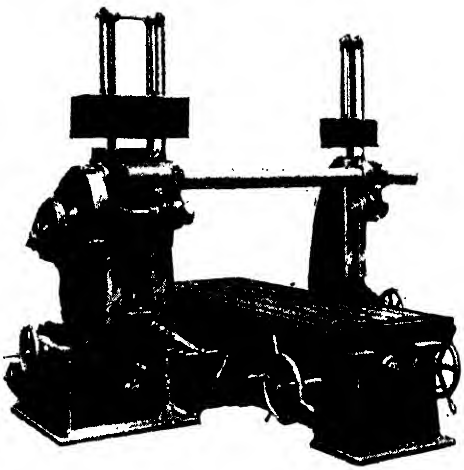
Lincoln Machine. Fig. 66 gives front and end views of a Lincoln machine (John Holroyd & Co., Ltd., Milnrow). The bare outline resemblance to the lathe model will be noted. There is a head, A, carrying a vertically adjustable slide or saddle, B, which has two bearings for the spindle, D, that drives the cutter arbor, the opposite end of the latter being supported by a point centre held in a slide, E, bolted to a standard, F, adjustable along the machine bed to suit different lengths of arbors. As the spindle height is altered by moving B, so the latter keeps E at a corresponding height by means of a connecting steady-bar, G, clamped in the split bearings of B and E. B is moved up or down by a vertical screw actuated by mitre wheels from the hand wheel H. The spindle is revolved from the three-speed cone pulley J, having a pinion gearing with a large spur wheel, K, on the spindle, affording a power gain of 4½. The cone pulley spindle is carried in bearings held by pivoted arms pinned to the bed of the machine and to the slide B respectively, to keep the gears



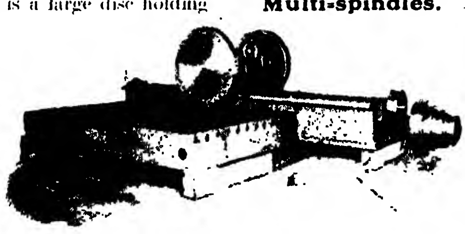
66. LINCOLN MILLER

in mesh at all vertical positions of B. The table, L, having two tee-slots, slides upon a saddle, M, adjustable along the bed by a screw turned with the handwheel N. The table L has a screw feed, operated by hand through spiral gears and wheel, O, or by power through the belt cones P and Q, Q driving a worm gearing with a worm wheel above it, and thence through spur gears to the table screw. The worm, R, is supported in pivoted bearings, in order that it may be suddenly dropped downwards out of mesh with its wheel, the dropping being effected by a dog bolted at any position on the table L, so as to arrest its feed at a predetermined point. The attendant may thus leave the machine at work to attend to other duties, and when the length of work is milled the table stops and the cutter revolves idly, pending the operator's attention.

In some lighter machines of the Lincoln type the spindle and back support are carried in square box bearings which slide within slots in the vertical housings, and a steady-bar to tie the standards together is not used. In heavier machines the driving head is movable on the bed, while the table slides on a fixed bed [67] made of considerable length, to accommodate long and massive pieces. The spindle bearings in this example are counterbalanced by weights attached with chains passing up over pulleys. The steadying standard is removable, to leave the table free for large work which may overhang considerably. An end or face cutter is then used in the spindle. Fig 68 is a step further, and here no steady bearing is used, and the work, being inconveniently large to move, is fixed instead, and the head is fed along past it, upon a slide bed. The cutter head is a large disc holding several dozen tools pinched with set-screws. Heads are made in this manner to several feet in diameter, and the machines are used for finishing off large surfaces on castings and forgings, including columns, standards, brackets, etc. As the ends of these are done, the term *ending machine* is often applied. *Rotary planer* is another name. There is no height adjustment in 68 the work being packed up as necessary. A good many machines are constructed with double heads, to operate upon both ends of a single piece of work simultaneously. One or both heads are adjusted to suit the length of work.



67. HEAVY LINCOLN MILLER
(H. W. Ward & Co., Birmingham)



68. ROTARY PLANER
(Newton Machine Tool Works, Philadelphia)

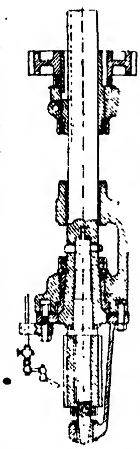
Plano-millers. The slab-millers, or plano-millers resemble planing machines in their bare outlines, possessing a travelling table, fixed housings, adjustable cross-rail, and tool saddles, but the last-named support spindles instead of single-edged tools. The work done is similar to that of a planer, with the added advantages which may be gained by the use of gang mills built up on an arbor. A massive plano-miller, shown in 71, embodies the points just enumerated. The machine is driven from an electric motor at the end, the table being given suitable rates of speed for cutting, and means of rapid return by hand. The cross-rail is moved up or down the faces of the housings similarly to planer practice, and the spindle runs in two bearings on a saddle held on the cross-rail, while a third bearing supports the end of the cutter arbor. The spindle is driven through gears connecting to a large wheel mounted between its two farther bearings, the hinder one not being therefore visible in the photo. Several taps are placed above the cutter, to turn on a flood of lubricant, which is supplied from a pump through a flexible pipe. Where objects of greater height or width are concerned, the machines assume taller housings, with more space between, and the tables increase in length, the planer model still prevailing. The vee ways, common to planer beds, are, however, omitted in favour of flat ways, with gibbed edges, to prevent any tendency to lifting or chattering. When a considerable width of cross-rail necessitates the use of a very long arbor, an intermediate bearing is placed between sets of cutters, when possible, to give ample support. Thus, in milling the ways of a lathe bed there would be two batches or gangs of cutters separated by a considerable interval, and the opportunity is taken of putting in an additional bearing. Spindles of this character are given an endlong motion, to effect adjustments of cutters. To enable this to be done without affecting the drive the spindles are splined to slide through the bushes or sleeves of their driving gears.

Multi-spindles. A practice copied from the planing machine is that of duplicating spindles, placing two on the cross-rail and one on each housing, the two latter being employed either independently with a face cutter each, or in conjunction, supporting a long spindle. Fig. 72 illustrates a four-spindle machine (Ingersoll Milling Machine Company, Rockford, Ill., U.S.A.), embodying these provisions. A large piece of work may be milled on four faces simultaneously, obviously with a great saving in time, as compared with the method of shifting the work about to suit a spindle. A drawing of a vertical spindle, fitted to the saddle of a plano-miller, is given in 69, from the practice of John Hetherington & Sons, Ltd., Manchester. The spur gear at the top is keyed to a sleeve running in the bearing and driving the spindle by a key. Below is an intermediate bearing, and underneath that a nose bearing, in which the spindle revolves inside a taper bush. Lock-nuts take up wear. The nose of the spindle is bored out tapered, to receive

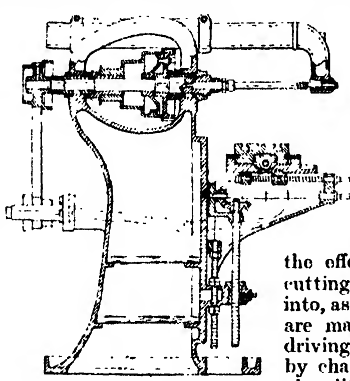
a cutter arbor, held in with a cotter, as seen, and the arbor holds its cutter with a key. If the cutter is short and used for face milling, no other support would be necessary, but if it is long an extra stay [69] is bolted to the bottom of the spindle bearing and extended downwards into a hood, with a tapered bush, in which runs the end of the arbor. This style of fixing is much used for profiling, in which a long cutter mills the edge of work.

Pillar and Knee Machines. There is a large amount of work which cannot be conveniently handled on the foregoing machines, owing to the form of the parts, and we therefore find that an increased range of usefulness is obtained by making the work-table adjustable up and down besides its longitudinal and cross motions. This style is termed the *pillar and knee machine*, the knee sliding upon ways on the vertical face of the pillar or column supporting the spindle.

The build of such machines will be clear from the drawing [70] and photos [73 and 75]. It will be noted that the spindle head resembles that of a lathe head, with cones and back gears; the cutter arbor is held in with a taper, and its outer end is supported with a split bush fitted within the overhanging arm, clamped in split bearings above the spindle bearings, thus allowing of endlong adjustment, or removal. If face mills are used in the spindle there is no chance to employ the arm. The knee, of approximately triangular form, slides with vee ways upon the vertical face of the pillar; it is moved by turning the squared shaft at the front, which revolves a horizontal shaft, driving bevel gears rotating the vertical screw, which passes through a nut held in a projection of the pillar. The other screw nearer the pillar is for stopping the motion at any predetermined position, settled by the location of the lock-nuts, which touch the lug that stands out from the pillar. In this way the operator may repeat any depth of cut on duplicate pieces. A transverse slide moves across the top of the knee, also by handle and screw, and a longitudinal table runs on this slide. The movement is produced by a central screw, turned with a handle at either end as is convenient, and the work, bolted to the top of the table, may be thus manipulated and fed under the cutter in any direction. As the longitudinal feed of the top table is considerable, the operator's time is saved, and the work better produced by fitting a power feed, derived primarily from the cutter spindle, passing from the three-stepped belt cone on its end to one below, which drives a universal telescopic shaft connecting to a worm, worm wheel, and spur wheels working on the end of the screw. The telescopic shaft has ball joints, which allow it to angle and twist about in any direction—a necessity on account of the rising and falling of the table. An automatic trip device is fitted to drop the worm out of gear when desired, as mentioned in connection with 66. These points represent the principles of the design, but many modifications are present in machines by different makers. In the lightest types no back gears are used, and the tables are fed by hand levers operating pinions gearing with racks under the tables, the traverses being short; the name *hand miller* is applied to this pattern. These pillar machines are classified into two groups—*plain* and *universal*. In the plain there are only two tables moving at right angles [see also 73] (Cincinnati Milling Machine Company, Cincinnati, O., U.S.A.), but in the universals the top table is mounted on a secondary saddle with a circular base, which can be swivelled to turn the top table into angular positions, to permit of milling work out of the ordinary run, such as certain gears, of worm, and spiral forms, twist drills, etc., requiring the cutters to be placed angularly in relation to their work. To do this, *index centres* are necessary, shown on the table of the universal in 75 (Brown & Sharpe Manufacturing Company, Providence, R.I., U.S.A.). The principal ways in which machines differ from the type in 70 concern the feeds, which are not derived by belt cones in a great number of modern machines, but through gears, giving a positive drive. The necessary changes are obtained by nests of gears in boxes, any combinations required being obtained by sliding the gears or moving keys to throw different sets into engagement. Much heavier cuts are now possible as a consequence of using geared feeds, and advantage is taken of the extra capacities of the high-speed steels.



69 VERTICAL SPINDLE



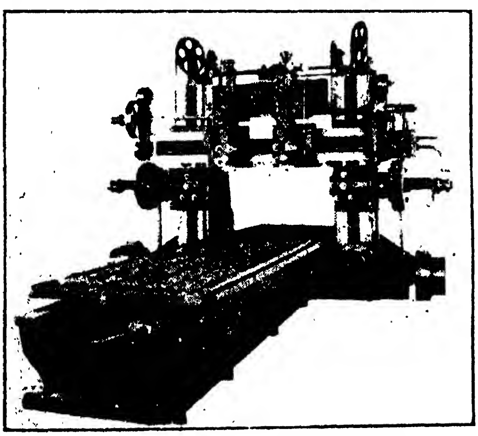
70. PILLAR AND KNEE MACHINE

The changes are also obtained without the trouble of belt shifting, small levers sufficing to throw the feeds in and out. The most complete machines have a power vertical feed in addition to the one given to the top table. Automatic trips are fitted, consisting of levers which are struck by dogs on the moving slides, the levers transmitting the motion to throw-out clutches, so that the feed is instantly stopped. As the dogs may be bolted anywhere on the table edges, the precise location at which the throw-out occurs is easily settled. It will be noted in 73 and 75 that the knee is tied to the overhanging arm by slotted braces, which impart additional rigidity, compensating largely for the one-sided nature of the design. These braces cannot be used when the knee is moving vertically. The vertical knee screw in 75 is of telescopic form, comprising one screw within another, the effect of which is to obviate the necessity of cutting a hole in the shop floor to pass the screw into, as in 70, where the screw is plain. Modifications are made in the latest machines, concerning the driving arrangements, an electric motor driving by chain to a series of change-speed gears which give different speeds.

Index Centres. The index centres, or dividing heads, bolted to the machine table, may be of plain form, consisting of a couple of heads with point centres, the chief one being fitted with a notched plate, by which settings are successively made to divisions of the circle. Thus, a plate with four notches at right angles is employed for work which has to have squares milled on it. When the plate has a larger number of notches, divisions may be effected into smaller numbers by skipping one or

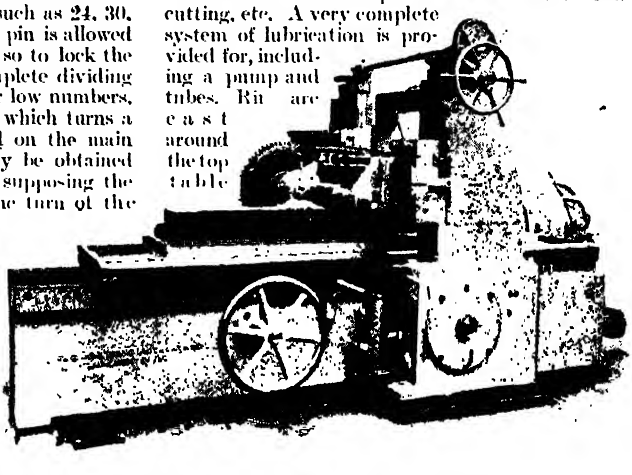
more of the notches. The plates are locked by spring catches in the various positions, and the work, lying between the point centres of the head and the tailstock, is held with a carrier, so that it must turn round with the plate. The notched plate device is suitable only for low numbers; above these, plates are used, consisting of steel discs drilled with several circles of holes, such as 24, 30, 36, and 42, or other sets. A spring pin is allowed to slide into the required holes, and so to lock the disc at each setting. The most complete dividing heads have a plate on the spindle for low numbers, and another on a secondary spindle, which turns a worm, engaging with a worm wheel on the main spindle. Very fine subdivisions may be obtained by this combination. For example, supposing the worm wheel has forty teeth, then one turn of the worm would rotate the spindle through one-fortieth of a revolution. A movement from one hole to another in the index plate would consequently result in a much smaller motion of the spindle. In addition to the intermittent movements obtainable by hand, there is a continuous motion possible in the universal machines, derived from the rotation of the table feed screw. This turns a set of gears at the end [75], connected up to the worm and driving the latter, and thence the wheel and spindle, at a uniform rate as the table travels along. Helical forms may be cut upon the work, such as in spiral gears, milling cutters, and twist drills, the ratios being varied by substituting different change gears, the case being similar to that of screw-cutting in the lathe. The spindle of the headstock may be angled up or down, for cutting tapered or bevelled work. The tailstock also has a range of vertical motion and angling to support the work.

Index centres of plain form are often of multiple type, possessing three or more spindles to carry duplicate pieces of work, which are cut simultaneously by mills mounted on the one arbor above.



72. FOUR-SPINDLE PLANO-MILLER

There are numerous fittings and attachments used with these pillar and knee machines. A vice, seen on the table of 73 and on the floor in 75, is employed to hold work that cannot be held so conveniently with bolts and clamps. The base is circular, and graduated to swivel to exact angles for setting the work. Attachments are held to the face of the pillar encircling the spindle nose, some carrying a vertical spindle driven from the main one, the vertical position increasing the range of the machine for some classes of work. A slotting device in which a short ram is driven up and down is useful for die-cutting, etc. A very complete system of lubrication is provided for, including a pump and tubes. Rims are cast around the top table and the base to catch the oil. The table rim connects with a pipe to a tank on which the pump is mounted to return the liquid (oil or soapy water) to the work. A moderate amount of lubrication, sufficient for some jobs, may be secured by the drip can, seen in 75 above the spindle.

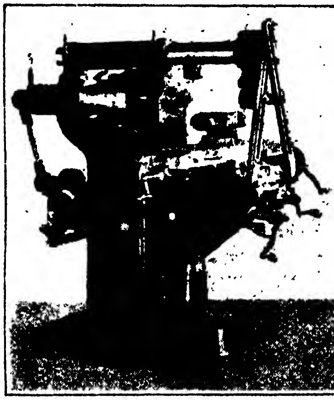


71. HEAVY PLANO-MILLER
(Sir W. G. Armstrong, Whitworth & Co. Ltd., Manchester)

Vertical Spindles. The vertical-spindle machines have some advantages not possessed by the horizontals, and there are consequently a number of designs of this class. They are especially favourable to the use of end of face mills, and the work can be seen clearly by the operator. Anything in the nature of grooving or recessing is suitable for a vertical spindle, and several edges of an object can be milled around in succession, or circular pieces finished. Points common to drilling machines and to slotters are found in the vertical millers; there is a revolving and vertically adjustable spindle and a base with slides. But the spindle is not fed down quickly like that of a drill, and the feeds of the tables are continuous instead of intermittent. A very complete example of a vertical-spindle machine is illustrated in 74 (Kendall & Gent, Ltd., Manchester). The spindle is belt-driven, like a drilling machine shown in the last article, but has additional back gears to gain power for heavy cutting. The spindle is moved downwards by sliding its lower bearing by means of a vertical screw moved with the large hand wheel seen on the bearing. A support is afforded to the bottom of the cutter arbor of a similar character to that described in 69, but the bearing is carried out and fastened by a hinge to the framing. The tables comprise two moving at right angles, and a circular one on the top, all moved by hand or by power through the stepped belt cones seen, actuating a shaft and gears in the tables, clutches being used to throw the feeds in or out. Rules are attached to the slides, and in conjunction with pointers indicate the amount of movement given. This is an alternative to the employment of graduated discs on the feed screws, such devices being used on most high-class machines now,

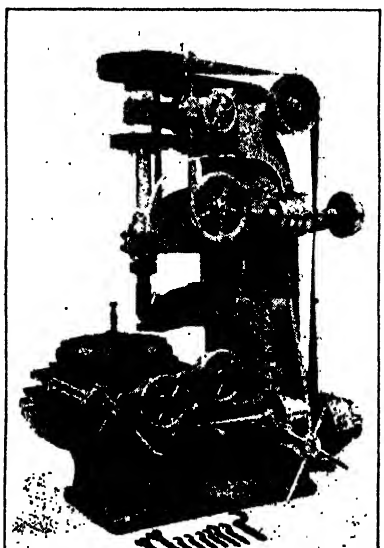
Fig. 72 represents a very large Belgian machine having points in common with the last illustration; it is driven from an electric motor seen to the rear, operating through change-speed gears (enclosed) and thence the belt which passes up over the guide pulleys to the spindle. The back gears for the latter are enclosed in the sliding head, which, on account of its massiveness, has a power travel for quick adjustment up and down. Its weight is counterbalanced by the weights passing into the floor below the machine. The table feeds are effected by the hand wheels, or automatically by power in the manner previously described.

A class of machine not exactly like either of the designs shown has a vertical movement to the tables, which are carried on a knee like the pillar and knee machines, the movement being used to accommodate work of various thicknesses, while the feed, when required, is imparted to the spindle slide.



73. PLAIN MILLING MACHINE

Profilers. The *profiling* machines constitute an important group. They carry saddles, which are coerced by the action of a tracer pin [see **272**, page 3403] pressed against the copy or form piece by a weight, or by the attendant holding a lever, and the outline of the copy is reproduced on the work by the milling cutter; both the work and the copy are bolted to the sliding table. A profiling machine (by James Archdale & Co., Ltd., Birmingham) is shown in **77**, one of two-spindle type, one of the spindles carrying a roughing cutter and the other a finishing cutter. The table is travelled along by the hand wheel at the side, operating a rack drive through the spur gears seen dotted. The two milling spindles are driven by endless belts from a long drum at the base, which accommodates their sliding movement. The spindles are carried in vertical slides; these again are supported on light horizontal slides, which move upon another heavy saddle running on the cross-rail. The heavy saddle is moved across for adjustments for bringing either spindle into position by the ball handle seen in the front view, rotating spur gears connected with a rack on the underside of the saddle. After thus bringing the main saddle into position, the attendant moves the light spindle slides during cutting, using the long levers seen standing out, these light saddles running on rollers. Balance weights are mounted on pivoted levers to counterbalance the vertical slides; the latter are fitted with stop screws seen at their right-hand sides. Profiling mechanism is used on the plano-millers previously treated, the mechanism including, of course, a tracer pin; weights pull the slides over into constant bearing against the cut.



74. VERTICAL-SPINDLE MILLING MACHINE

Circular Milling Machines. These have been brought into prominence during recent years, supplanting the turning lathe for some kinds of work. They are especially suitable for gear blanks, belt-pulleys, rope-wheels, etc., of light sections, which can be milled more quickly than they can be turned. A certain amount of circular milling is possible on ordinary machines, using a rotary table, but the special machines are more convenient and have greater capacities. In **78**, a circular miller by Ludw. Loewe & Co., Berlin, the cutters are held in the spindle of a headstock with belt cones and back gears, seen to the left of the figure, while the work is placed upon a mandrel driven from the spindle of the head to the right, the mandrel being supported at its free end by the bearing on the triangular bracket, this bearing, together with the head, being adjustable to and from the cutter for variations in the diameter of work. A series of rotary feeds given to the work is derived from the friction discs at the rear of the cutter headstock, transmitted thence to the work head, and driving a worm gearing with a worm wheel on the spindle.

Cam Milling. These machines, also, have two sets of spindles to drive the cutter and the work (if the latter is circular), and the cam outline is reproduced from a master, or copy, a principle similar to that described under profiling machines.

Screw Milling Machines. These have been largely developed during the last few years, cutting the threads of vee or square-thread screws by milling instead of using a single-pointed tool in the lathe. The output is considerably greater with the milling cutter. The machines have means for rotating the blank at a suitable speed, while either it or the cutter head travels along, ploughing out the spiral thread as it goes. The cutter is necessarily placed on an angle to suit the pitch of the screw. Some machines of this type can handle work up to 12 in. diameter by 48 in. long. *Twist-drill* milling machines are of an allied character; there are two cutters operating simultaneously in the two flutes of the drill, while the latter is slid longitudinally, and also given a twisting motion.

Gear-cutting. These machines are divisible into two classes, one having rotary cutters, the other planer tools, the latter being employed chiefly for bevel gears, which cannot be cut accurately with rotary cutters except by making special movements. Spur gears are cut on milling machines fitted with index centres, but the product is limited to rather small gears, and the method is not economical for manufacturing

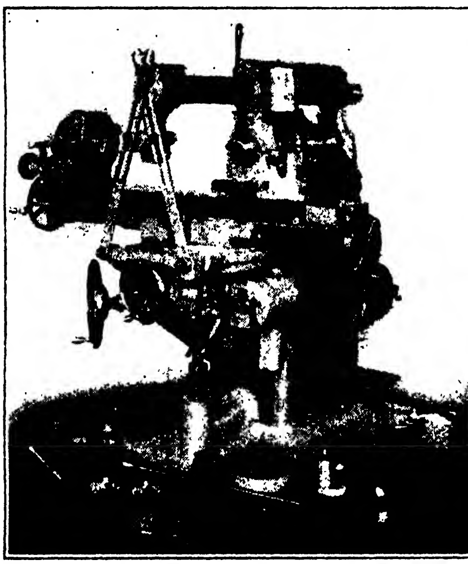
in quantity. Machines are semi or full automatic, the latter naturally involving many complications. A semi-automatic type, which is commonly used, is shown in **80** (G. Birch & Co., Manchester). The wheel blank is held on the horizontal arbor, and, if necessary, is bolted also to the slotted face-plate. On the other end of the arbor is a large dividing worm wheel, which is turned round a portion of a revolution through a series of change gears. After each partial turn a tooth space is cut by a mill held on the vertical arbor seen to the right, on the saddle that slides along the horizontal rail, either by the hand wheel seen, or by self-acting gears, which are tripped after each traverse. A machine of this description is also adapted to cutting bevel and worm gears if the cutter slide is made with a swivelling motion to allow of angular setting.

A full automatic spur gear cutter, by J. Parkinson & Son, Shipley, is shown by the photo [**79**]. The wheel blank is held on the horizontal arbor supported in the dividing head spindle to the left, and at its outer end in an upright steady-pillar. The height is adjustable to suit differing diameters of wheels by sliding the spindle-bearing saddle up or down its pillar through the screw and handle. The cutter is keyed on an arbor lying below the work mandrel, and having bearings in a slide which is given a slow motion during cutting and a rapid backward motion after a tooth space is cut. At the same time the blank is moved around by the amount of one tooth and another cut taken. The large dividing worm wheel, covered with a guard, is partly turned by a worm on a vertical shaft as the cutter slide moves back; change gears are set to determine the requisite amount of rotation to suit the wheel pitch. The movement is so arranged that the speed of the dividing is gradually accelerated at first, and then retarded, thus avoiding shocks to the parts. Another useful device is that incorporated for intermittent spacing: instead of cutting the teeth in regular order, some are skipped over, and every second or every fourth tooth cut, the intervening ones being cut subsequently as the wheel comes around. The object of this is to avoid risk of inaccuracies through the unequal heating and expansion of the blank at one location where cutting has proceeded on several teeth close together. A device is also fitted to prevent the cutter from feeding up as usual should the dividing mechanism fail to act through accident, which would otherwise result in a spoilt gear.

Machines built on this model are also arranged for bevel gear cutting, by making the cutter slide tilt up, so as to feed angularly, or else by swivelling the spindle head carrying the blank.

Spur gears are also cut with planing tools, but the action is not so rapid as by using milling cutters. In the Fellows machine the tool is the shape of a gear itself, and it rolls in contact with the blank while reciprocating, thus generating the true tooth curves.

As mentioned previously, rotary cutters cannot produce true bevel tooth curves on account of the change of form along the flanks; there are two or three machines, however, which get over the difficulty by imparting extra movements to the cutter to enable it to follow the taper of the cone, and make correct teeth. The planing method is one that produces accurate teeth, because the strokes all point to the apex of the gear cone, and a good many machines are built embodying the principle. In the Gleason design, a pattern or form-tooth of large size is used to guide the movements of the tool, and make it cut a similar profile on a reduced scale on the blank. Three formers are employed, one for use when blocking out the centre of the tooth spaces, and two others when tooling the flanks, which are done one after another. The wheel blank is mounted on a mandrel, which is rotated intermittently by dividing mechanism. A good many machines of similar character are made, but we cannot attempt to describe them here. There are also generating machines, cutting gears without the use of formers, the tooth curves being produced or initiated by the action of rolling movements of the blank against the tool. Worm and spiral gears are cut by rotary mills. They are done on machines with arrangements for rotating the blank at a suitable rate as the cutter operates. In worm wheel hobbing machines the cutter assumes the form of a worm, notched to make cutting edges, and it works into the wheel while rotating, just as though the two were driving together. Hobbing machines are made to cut spur gears, the blank revolving while the cutter rotates, and also feeds downwards to make the teeth straight.



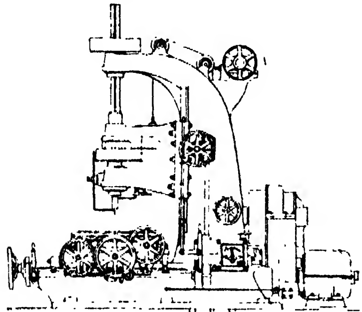
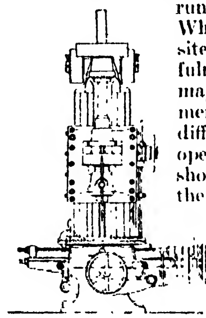
75. UNIVERSAL MILLING MACHINE

Miscellaneous Machines. Among other machines used in the machine shop are saws, screwing machines, and key-seaters. Saws of *band*, *circular*, and *hack* types are used for cutting out portions of metal, and for parting off bars, tubes, etc. The band saws resemble the familiar wood-working type, with stiffer tables, having power feeds, and different saws. Circular saws run slowly, and the beds embody provision for clamping pieces of work down while the saw cuts through. Hack saws use narrow flat blades. Lubrication is essential in cutting wrought iron and steel.

Screwing machines, used for cutting threads on bolts and bars, are made in diverse forms, but the general principle is that of a revolving die-head, carrying screwing chasers, which cut the threads on a piece held in a vice and moved along a bed as screwing proceeds. The chasers are constructed to fly outwards in the head on moving a lever, so that the bolt may be drawn back instantly after

threading. Either plain belt cones or geared drives rotate the die-heads. Tapping is done with long taps passed through nuts held in a vice. This sort of work is simple, but there are some classes of tapping in which danger of breakage of taps is incurred, and spring friction devices are introduced to let the taps slip should undue strain come upon them.

Key-seating machines, though not very old, have grown rapidly in favour. They supplant the ordinary slotting machine for the work of cutting key-ways in wheel bores, and avoid employing an expensive large machine for work which is far within its utmost capacity. The slotter is quite suitable for key-way slotting, but is an expensive machine to use on such small work. The key-seaters produce the same effect without anything like the massiveness of a slotter, and they possess certain advantages. The mode of operation is shown on page 3403 [**275**], and the machines comprise a horizontal table up through which the slotting bar reciprocates inside the wheel bore. Feed is given to the tool, or to the table on which the work is held. The top of the bar is supported above the wheel, so that a stiffer construction is afforded than that of the ordinary slotter tool when working in deep holes.

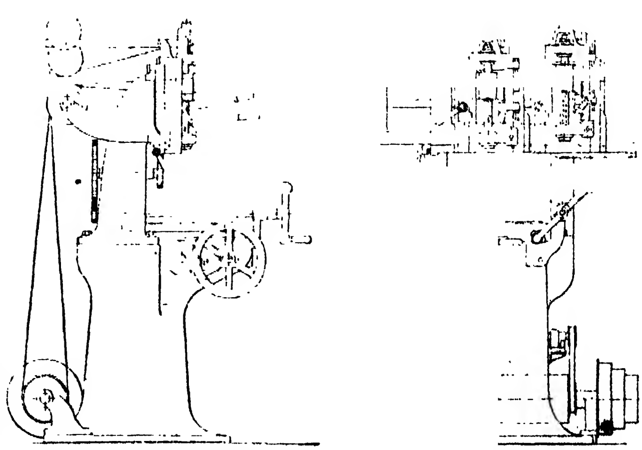




76. HEAVY VERTICAL-SPINDLE MILLING MACHINE

Grinding Machines. These constitute an important group existing in numerous varieties, for executing both plane and curved surfaces. The common grindstone, or gritstone, is not representative of any modern machines, since it combines no provision for precise and accurate grinding to exact forms and limits. Machines which u[se] artificial wheels moulded of emery, corundum, carborundum, alundum, etc., are capable of very high-class work, and also of rapid reduction of material, due to the accuracy of shape of the wheels, the forms into which they can be moulded, and their durability. Grinding machines are not designed precisely like the types of machines hitherto shown because regard has to be paid to the fact of vibration introduced by the high speeds, and the necessity for protecting slides and bearings from flying dust, which would quickly ruin them. There is also a difficulty on account of the rise in temperature occasioned by the grinding action, which tends to distort the work and affect its truth. A copious supply of water is therefore necessary, and means must be provided for catching it again as it runs off the work and wheel. Guards are required over the wheels, both to prevent the dust from flying and in case of accidental fracture of the wheels.

Plain Grinders. The plainest grinders are those mounted similarly to natural grindstones, with a wheel fastened on a spindle revolving in two bearings, a belt-pulley affording the means of driving. The work is held against the wheel by the hands alone, a very suitable method for some kinds of jobs. The addition of a plain rest increases the usefulness of the machine, enabling work to be pushed up readily without its slipping about. The rest must come very close to the wheel, and the latter must run in a direction towards the rest. When two wheels are provided at opposite ends of a spindle, the range of usefulness is further increased; the wheels may be of similar kinds, for a couple of men to work at simultaneously, or of different kinds or grades for particular operations or classes of work. Thus, **81** shows a machine with a disc-wheel at the left-hand side and a face or cup wheel at the right, both with work-rests. A steel guard is placed around the disc-wheel to prevent the fragments from scattering by centrifugal force in the event of bursting. Many bad and occasionally fatal accidents have occurred through the breaking of grinding wheels, and it is very common to encase them in the manner shown, or by equivalent methods. In this machine there is also a small exhaust fan at the rear of the pillar, which sucks through the pillar from hollow troughs underneath the wheels, and also through the hollow base of the face wheel rest, all the dust produced in grinding being thus instantly removed and deposited wherever convenient. In what are called *tool grinders*, having one or two wheels, water is supplied from a pump, or by a tank, and the wheel, being thus constantly flooded, does not scatter its dust about in the air.

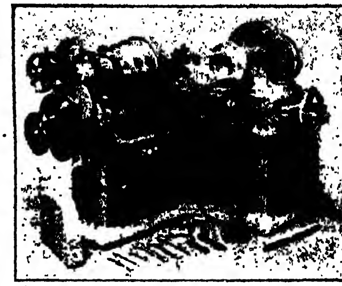
Disc Grinders. Although very true surfaces cannot be produced by holding work in the hand against the periphery of a disc-wheel, rapid roughing can be done thus, and a flat finish given by holding the piece against the side of the wheel. A type of machine that does this class of work very accurately and rapidly is the disc grinder, which has no solid wheels, but sheets of abrasive cloth cemented on to steel discs, running at a much



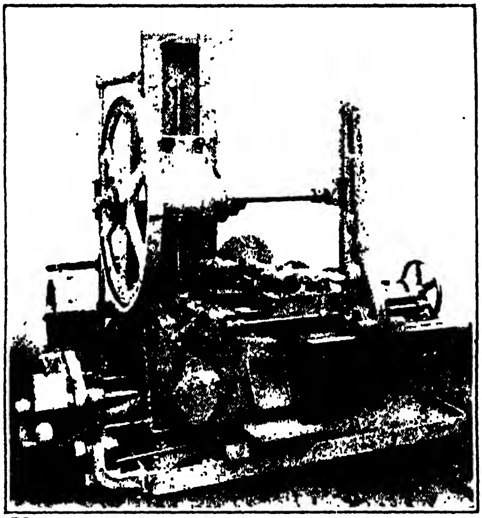
77. TWO-SPINDLE PROFILING MACHINE

higher speed than that safe for moulded wheels. Both rapidity and accuracy are attained thus. Complete views of a disc grinder have been given on page 2792, which may be referred to. Some machines have two discs set opposite to each other, the work being slid between, and thicknessed accurately and smoothly. A good amount of work that was formerly sent to be shaped or milled is now finished more rapidly and as accurately by disc grinders. Keys, cottars, half-brasses, glands, nuts, etc., are among the objects so ground. The discs of emery or other cloth are cemented on the steel discs (removed from the spindle for the purpose) by keeping them in a press, a spare set of discs being employed to avoid waiting for the cement to set. Old worn-out paper or cloth is removed by scraping, after the disc has been placed in hot water.

Grinders for Plane Work. The addition of a slide-rest to an ordinary grinder enables it to work more accurately, and grind plane faces, but the length of travel is necessarily limited. Hence, for flat surfaces of considerable length, a machine resembling a planer or miller framing is required, with a table to carry the work past the wheel. Some of the smaller machines of this class have a single upright upon which the wheel saddle slides up and down, to accommodate various depths of work placed on a table below. Larger machines have two standards, like planers, and the wheel is supported on a cross-rail, the movements somewhat resembling those of a planer. Fig. 82 is an illustration of a large plano-grinder (Friedrich Schmaltz, Offenbach-on-Main), built on the planer model, the table, housings, and cross-rail being obvious. The wheel spindle, running in bearings upon the saddle, is rotated by an endless belt coming down from the countershaft above, passing around two idle pulleys attached to the back of the cross-rail, round the spindle pulley, and round a tightening pulley on the base of the machine. By this arrangement the alteration in height of the cross-rail on its housings makes no difference to the drive. The wheel spindle is prolonged on the left-hand side, to pass through the pulley and the bearings as the wheel saddle is moved across the rail. The latter movement is effected by the screw seen lying within the rail, and driven from gears—worm and bevel—off the wheel spindle. The stop rod above the saddle has dogs, which are struck by a stop on the saddle, reversing the motion through a clutch and bevel gears, shown dotted at the end of the screw. The table is actuated in planer fashion by the fast and loose pulleys and striking gear. In the end view, the wheel guard is not shown, but it is in the side elevation, together with the water pipe, dotted. Flat work of various kinds, as slide-bars, rods, guides, etc., are ground with accuracy and rapidity, with the added advantage that they may be hardened beforehand without affecting the tooling. A planer would not be able to tackle hardened work. Machines of this class are also constructed with a face wheel, the spindle of which stands vertically, an advantage in some instances.



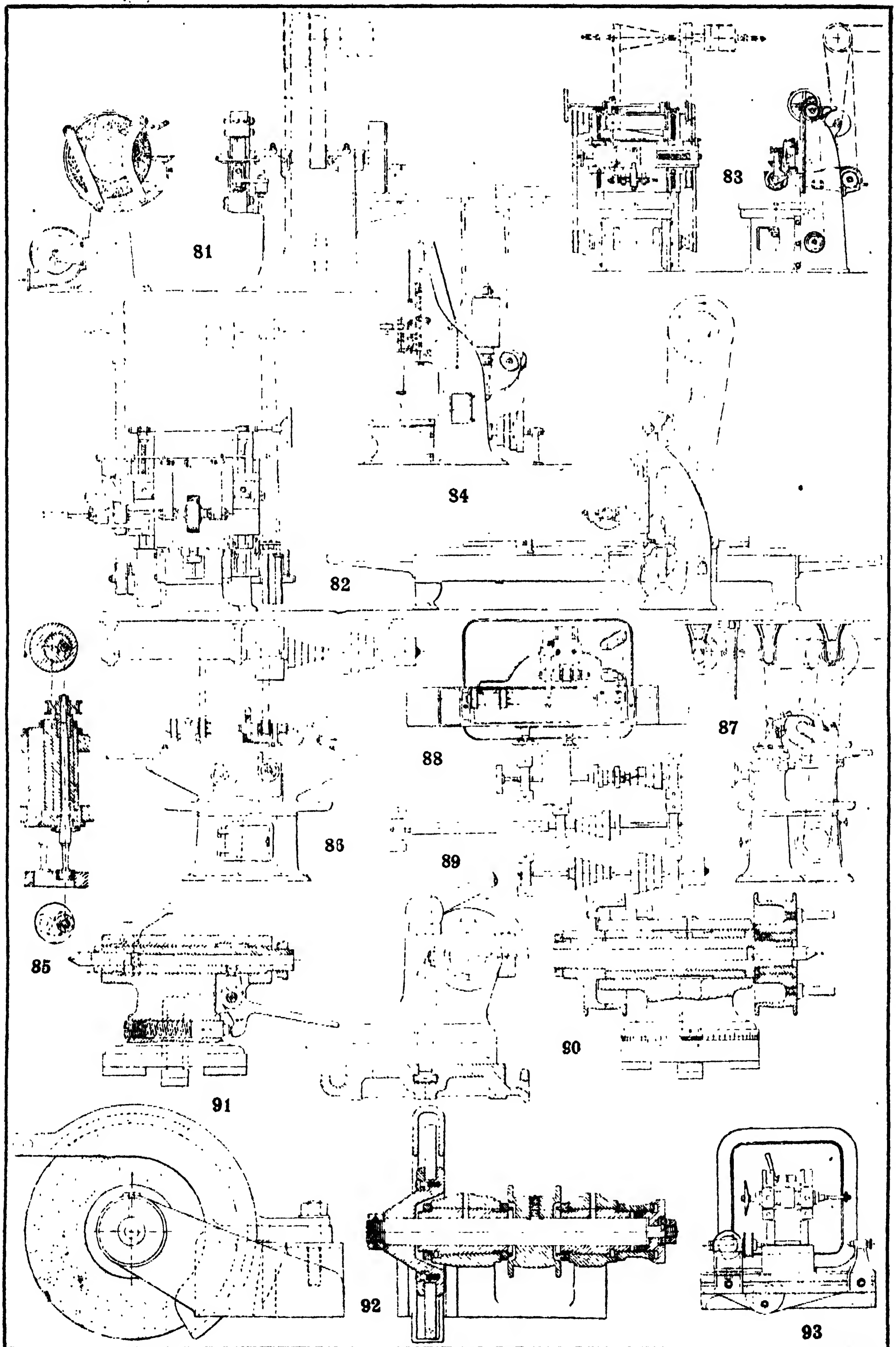
78. CIRCULAR MILLING MACHINE
(Ludw. Loewe & Co.)



79. AUTOMATIC SPUR-GEAR CUTTING MACHINE

80. SPUR-GEAR CUTTING MACHINE

Piston - rod Grinder. Flat surfaces of another kind, on circular discs or rings, such as piston rings, are ground with a machine [83] (J. E. Reinecker, Chemnitz - Gablenz) in which the table rotates, carrying the work upon it, and the grinding wheel above is traversed along the cross-rail by hand, or automatically. The design reminds one at once of the boring and turning mill. A neat arrangement is fitted for automatically decreasing the rate of revolution of the table as the wheel gets nearer the periphery, where the speed of the work should lessen, to maintain a correct grinding ratio. A pair of reverse cones is used, one on the countershaft, shown dotted, and one on the top of the machine, a belt connecting the two. In the position in which it is shown, the larger end of the countershaft cones drives the machine cone at a quick rate, and the latter cone transmits the motion by a three-stepped pulley on its left down to a similar pulley actuating bevel and spur gears gearing with the table spur ring. When the wheel saddle begins to travel outwards, it operates a belt shifter, which gradually moves the belt along the cones, so continually lowering the table speed. The movement of the wheel saddle across the rail is by a screw and hand wheel, or through the small belt cones on the right of the machine, driving from the bottom cone up to the top one, thence horizontally, and down again by a shaft to bevel gears and a worm wheel working on the cross-rail screw. The grinding wheel is rotated by its pulley, belted from a long drum at the back of the machine, driven from the countershaft. The drum is fitted with adjustable bearings, sliding to and fro, to accommodate the belt length to suit the relative position of the cross-rail

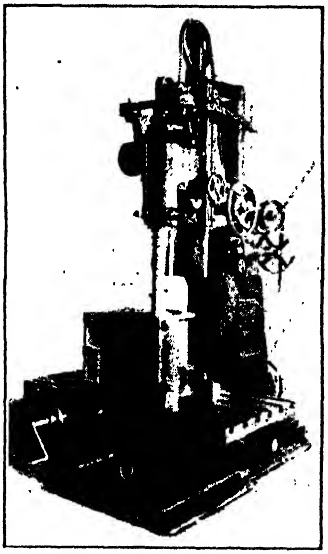


GRINDING MACHINES

81. Common grinder **82.** Plano-grinder **83.** Piston-ring grinder **84.** Hole grinder **85.** Eccentric spindle for hole grinding **86-89.** Universal grinding machine **90** and **91.** Headstock and poppet **92.** Wheel head **93.** Plan of cutter grinder

up or down the housings. The wheel spindle is not mounted in fixed bearings on the saddle, but in pivoted ones, which allow a very fine up or down movement to be given by an adjusting screw.

Hole-Grinders. Machines for grinding out holes are increasingly numerous, because of the extent to which hardened work is now used in the best practice, and also because it is found that finer results can be obtained by grinding than by boring. One type of machine which is rather common [**84**] has a circular table revolved by cone pulleys and bevel gears. Above the table there is a grinding spindle running in a long sleeve, and supported on a saddle that has a cross motion, upon a slide having an up and down motion upon the vertical frame. The slide is counterbalanced with a weight inside the frame. The spindle is driven by belt from the vertical drum, the latter being rotated by a belt from one of the cone pulleys at the base, the belt passing up over angle pulleys and around idle pulleys. The vertical feed is self-acting, and is provided with a throw-out by dogs and reversing bevels, in a manner described in connection with other machines. If a piece of work is therefore bolted to the table, and the spindle set sideways sufficiently to let the grinding wheel touch the interior wall of a hole in the centre of the piece, this hole may be ground out circularly by revolving the table and wheels [see **282**, page 3404]. If, however, the work is too large or awkward to revolve upon a table, the planet spindle device [**283**, page 3404] is employed, and also for pins, as in **281**. The work is fixed, and the grinding wheel, besides its own rotation at a high speed, describes a circle at a low speed, the range of the circle being variable to let the wheel move in a larger or smaller diameter. The usual pattern of spindle [**85**] is of triple form, comprising the wheel spindle—the innermost one, running in conical bearings within another spindle, but out of centre, a further outside sleeve embracing the other. The outer sleeve is rotated slowly, the grinding spindle rapidly, and the latter is increased or diminished in range by turning the intermediate spindle to bring the grinding spindle out towards the circumference, or in nearer the centre, where its throw is lessened. The means of alteration are not shown in the drawing, but they usually include worm gears. A hole-grinding machine fitted with a planet spindle is illustrated in **94**, grinding out a cylinder bore. Horizontal forms are useful in many cases, the parts of the grinding head being more accessible than in the verticals. In the last two or three years several firms have brought out machines specially for motor-cylinder grinding, boring being dispensed with altogether in many cases, so that although the hole-grinders were originally developed for engine work, to deal with the hardened bushes in rods and link motions, their scope has been greatly extended.



94. HOLE GRINDING MACHINE (F. Schmaltz)

Link Grinders. A related class of machine is the link grinder, employed for finishing out the curves of slot-links after hardening. The correct radius is produced by using a long pivoted rod, which coerces the motion of the link upon a table, while the grinding wheel simply revolves within the slot. Some machines specially built for rod work possess two vertical spindles, the centres being adjustable to suit the rods: both bushes are ground out at one setting of the work.

Cylindrical Grinders. The grinding of cylindrical work is, perhaps, the most important class of this process in the machine shop, just as lathe work predominates over planing, shaping, and slotting. It is done on machines that bear resemblances to the lathe. In fact, all the early grinding was done in lathes by adopting the device of putting a grinder head on the slide-rest, a practice still followed by a few firms. An ordinary lathe, however, is not fitted to withstand the damaging effects of grit, and it has several inconvenient points which are not found in proper grinders. The obvious necessity for cylindrical work is two heads, with point centres, and a means of driving and of feeding the wheel along the work. This is met in two different ways: in the smaller machines the heads are placed upon a long table which slides past a fixed wheel, in the larger ones the heads are stationary, while the wheel travels on a saddle. The reason for this difference is chiefly one of convenience, because it would be awkward to have a long table projecting by a considerable amount beyond its bed at each travel, and requiring a lot of space left in the shop.

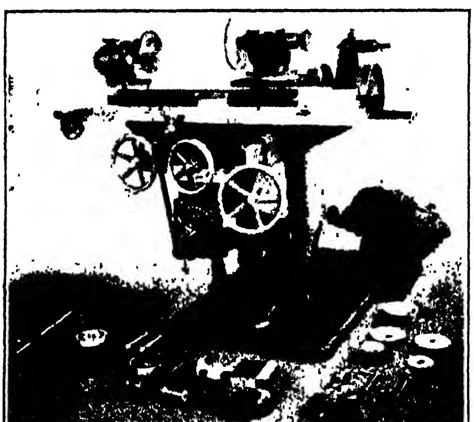
A machine belonging to the class with moving table, is shown in **86** to **88** (C. Birch & Co., Manchester). Its capacity is 10 in. diameter, by 24 in. long. The bed supports a long sliding table upon a vee and a flat, and upon this table an upper table is fitted in such a manner that it can be swivelled to bring its head and tail stock lying angularly in relation to the wheel head at the rear, enabling tapered work to be ground. The wheel head can be swivelled around on a circular base, and moved to or from the table, by the hand wheel seen in front. The other hand wheel moves the table along; it is also fed automatically by the four-stepped cone pulley [**87** and **88**] which operates gears driving a pinion meshing with a rack under the table. An automatic reversing device is incorporated, which, by means of dogs on the table, keeps the latter sliding to and fro while the grinding wheel is reducing the work. At each reversal, a minute movement is imparted to the wheel slide to make the wheel get in deeper. The countershaft arrangements include a long drum of small diameter, for driving the headstock and allowing the belt to slide as the table moves along, and a large drum sufficiently long to accommodate the varying positions of the belt on the wheel spindle, as the head is angled. There is also the belt for the four-stepped cone mentioned, and a small belt for a pump. On referring to **89**, which is a view looking down on the lay-out of the countershafts, the uses of the various pulleys will be obvious.

There are two kinds of these machines, *plain* and *universal*. The plain have no swivelling movement to the wheel slide, or to the headstock, thus

rendering them incapable of tackling certain angular work which the universal is fitted to do. The headstock of the machine [91] has its upper portion swivelling upon a circular graduated base for angular settings. The hollow spindle is driven either by the pulley at the left-hand end, or the pulley may be locked with the plunger seen, and the work rotated on dead centres by the other pulley, which runs loosely, and drives a carrier on the work. The head is clamped to the table with a tee-headed bolt and a handle. The spindle bearings are split, to take up wear with set-screws. Fig. 91 gives a section of the poppet, which differs from that of a lathe in having a spring-actuated lever to press the centre up to the work, the object being to allow the work to expand lengthwise as it heats up, without bending, as it would if the poppet barrel did not give way. The nut on the tail end of the barrel prevents it going too far. For work which does not need the spring device, the barrel is clamped firmly by the ball lever squeezing in a split lug at the nose. The wheel head [92] has a spindle running in split bushes, tapered on the outside and fitted with nuts to draw them endwise for take-up. The wheel is gripped in a concave disc, and guarded around as much of its diameter as possible. A fine endlong movement is given by a graduated disc and micrometer screw at the opposite end of the wheel, so that the latter may grind minute amounts from shoulders. Larger heads have a wheel at each end of the spindle. A small spindle is provided with these grinders to true out holes in work, held in a chuck screwed on the nose of the headstock spindle.

A photo of a heavy grinder, constructed on the model previously mentioned, with travelling wheel head, is shown in 94. Steady rests are fitted to prevent the work from springing away and chattering.

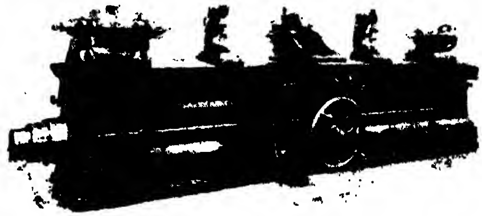
Tool Grinders. *Cutter* grinders somewhat resemble the machines just discussed, but they are lighter in construction. A typical machine is that in 96, possessing head and tail stocks and grinding head, with two wheels. A plan view of a table and head is given in 93, which is representative of the usual pattern. The centres are carried out on



96. ELECTRICALLY-DRIVEN CUTTER GRINDER

special heads, and the top table swivels for doing angular cutters. A reference to the article on page 3401 will enable the reader to understand the application of the various parts of these machines.

There are other types of machines for grinding tools, including twist drills, which are gripped in a holder, and given a peculiar twisting motion against



95. UNIVERSAL GRINDING MACHINE

the grinding wheel, to sharpen the lips at the end. Other machines grind lathe and planer tools by movements embodied in the mechanism, graduated circles giving the means of finding what angles are ground.

Polishing Machines. Years ago all the bright parts on finished work were got up with the file and emery cloth, but the greater part is now polished on special machines, using either wheels, bobs, or belts. The wheels are of wood, covered with leather, on which is glued emery or other fine powders or compositions. The bobs are built up of calico discs, which accommodate themselves to awkwardly-shaped work. Belt machines have long endless bands, charged with polishing material, and running around several pulleys. On a long stretch between pulleys, the work is applied by hand to the belt, which twists and bends around and into curves and hollows in the work.

Shop Appliances. There are numerous auxiliary appliances used in machine shops to enable the work of the machine tools to be facilitated. Some of these are regular machines, as the *bar straighteners*, which true up bent bars and shafts ready for the lathe; the *cutting-off* machines that part off bars to definite lengths for various purposes, and the *centring* machines for drilling and countersinking holes in the ends of shafts, etc. *Mandrel presses* are used, comprising an arched frame holding a vertical ram that can be forced down by rack and pinion to push work mandrels into or out of their objects, instead of driving them with the hammer. When, however, the latter practice is followed, by the aid of a lead or copper hammer, *mandrel stands* are brought into use: these are hollow pillars, provided with a number of differently sized rings, placed on the top, one of suitable size being selected that will allow a given mandrel to pass through and hang down while the work is supported on the face of the ring.

In shops where a good system of lubrication for the cutting tools is adopted, *oil separators* are installed. They have vessels, revolved at a very high speed, which, when oil-soaked chips from the machines are placed inside, whirl the oil outwards, by centrifugal force, through perforations into an outer receiving vessel, leaving the chips dry. The oil is thereby largely saved, ready to be used again.

Shop stands are installed in most shops nowadays; they are fitted with shelves or racks to carry pieces of work, or tools and appliances, and save the damage and untidiness caused when these things are allowed to knock about on the floor. In the best practice, each lathe and machine is supplied with a stand close to it, and convenient to the operator.

Continued

A SHORT DICTIONARY OF MACHINE TOOL PRACTICE

See also Dictionary of MACHINE AND FITTING-SHOP TERMS, page 3409.

ADJUSTING SCREWS—Used for moving slides and for setting parts to definite positions.
Aligning — Getting parts in line, such as lathe spindles, etc.
All-gear Head—A lathe head without belt stepped cones, but gears only, to obtain the speed changes.
Apron—The part of a lathe carriage which hangs down in front and carries the clasp-nut and gears for sliding and surfacing.
Axle-grinding Machine—A design somewhat resembling that of a lathe, but with two grinding heads instead of turning rests.
Axle-turning Lathe—Used for rapidly finishing railway axles, usually turning both journals simultaneously.

BABBITT METAL — Employed largely for spindle bearings.
Back Centre—The hinder centre on the poppet in lathes and grinders.
Back-gear—Toothed wheels used to gain power and transmit it back to a spindle.
Backing-off Lathe—One with a reciprocating slide-rest, to cut the clearance behind the teeth of cutters.
Backshaft — The feed-shaft when placed at the back of a lathe-bed.
Ball-turning Rest—A swivelling slide-rest for turning spherical portions.
Band-saw Machines—Largely employed for cutting metal.
Bed—Any base or lower portion on which slides are set or moved.
Bell Chuck—A hollow chuck in which work is gripped with a number of set-screws set radially. Also termed *cup chuck*.
Belt Polishing Machine—A type on which runs an endless belt charged with polishing material, adapted to go into curves which could not be touched by wheels.
Belt Shipper—A handle moving forks which "strike" or push a driving belt from one pulley to another.
Bench—A prefix applied to certain small machines, as bench drilling machine, bench lathe, bench grinder, which are not fastened on independent standards.
Bevel Gear Cutting Machines—These use either rotary cutters or, with more accurate results, planer tools.
Bolt-screwing Machine, or Bolt Cutter—One which cuts the threads on bolts, revolving in a spindle, by means of dies in a sliding carriage, or vice versâ.
Boring—Performed either in the lathe or in special machines.
Boring Bar—A cylindrical bar in which boring cutters are fixed. The bar may have a large head to carry cutters; the head may slide instead of moving the work.
Boring Head—A cylindrical head carrying a number of cutters around its periphery.
Boring Lathe—One used for preparing wheels for turning. It only bores and faces the hub. A slide-rest or a special poppet is fitted.
Boring Machines—Either of horizontal or vertical types, with one or several spindles.
Boring Mill—A lathe having its axis vertical, with table, and cross-rail carrying a tool-saddle.
Boring Rest—Used to steady and support either work or boring tools.
Box Tools—Cutters held in cast-iron boxes with steadies to ensure uniform results in turning.
Brass-finisher's Lathe—A type of lathe with a chasing rest, and usually a turret.
Breaking Piece—A pin or portion introduced into mechanisms, such as planers, to shear off when a dangerous strain accidentally comes on the driving gears.
Break Lathe—One with a wide gap, and an extra rest mounted on a pillar by the face plate, besides the rest and poppet on the bed.
Broaching—Smoothing out round holes with broach or reamer. In America the word means *drifting*, and broaching machines are employed.
Bush Grinder—A machine for lapping or grinding out bushes in hardened work, with a grinding wheel.

CABINET LEGS—Machine standards which are cast as cupboards for the reception of tools, etc.
Cam Cutting Machines—Either milling or grinding machines using formers.
Capstan Rest—A tool-rest carrying several tools in a circle. Also termed a *turret*.
Centring Machines—For drilling centre-holes in shaft-ends preparatory to turning or grinding.
Chamfering Machine—A type of lathe employed to chamfer or bevel nuts and bolt-heads.
Change-wheels—Toothed gears used to obtain speed ratios in screw-cutting, etc.
Chasing Lathe—One used for the production of screws by a die, or with tools traversed from a hob.
Chuck—Any appliance used for gripping work to be tooled.
Chucking Lathe—A face type of lathe employed for tooling objects held in a chuck by one end only.
Chucking Tools—Long drills and reamers used in *chucking lathes*.
Circular Milling Machine—A design in which wheels, etc., are rotated, and cut by milling cutters, instead of turning in the lathe.
Circular Motion—A fitting on a shaper which rotates to shape curved pieces.
Clamping Plates—Employed on most machine tools to hold work securely during tooling, or to grip the tools in their rests.
Clasp Nut—A divided nut which may be disengaged at will from a guide screw.
Cold-iron Saw—A circular saw, rotating at moderate speed (unlike the hot-iron saw), for sawing castings and forgings.
Collet—An intermediary fitting to hold cutters, drills, dies, etc., in spindles.
Combination Chuck—A lathe chuck, the jaws of which can be operated independently or simultaneously at will.
Combination Machines—Those which are capable of performing various operations, instead of only one, as boring, drilling, and milling, planing and grinding, planing and slotting.
Compound Rest—A slide-rest with superimposed slides, affording movements in two directions.
Concentric Chuck—One in which the jaws are moved simultaneously. It is also termed *self-centring*.
Cone-plate—A form of steady-rest, comprising a disc bored with differently-sized taper-holes and mounted on a bearing-pin. It is set upright facing the lathe-head, and one taper-hole receives the end of a piece of work, which is then drilled.
Countershaft—An intermediate shaft with belt pulleys by which speed changes are obtained, and machines started and stopped.
Cut-off Rest—A transverse rest used in capstan lathes to part off work.
Cutters—May be turning tools held in a bar, boring tools, facing tools, or milling cutters.
Cutting-off Machine—A type evolved from the lathe. It has a hollow spindle and a cross-slide, parting off shafts and bars with perfect accuracy.
Crankshaft Lathe—This is a massive form, with a number of slide-rests.
Cylinder-boring Machine—Either of horizontal or vertical design, the latter being preferred for very large bores.

DEAD CENTRES—Those which do not revolve, as opposed to live centres.
Diamond Tools—Diamonds are employed to true up grinding wheels of emery, corundum, carborundum, etc.
Die—A screw-cutting appliance used in machines.
Die-head—One which holds several chasers radially, these being removable for sharpening, and may sometimes release or move outwards to clear the thread after cutting it.
Disc Grinders—Machines employing discs of steel upon which sheets of abrasive cloth are cemented. Very accurate results may be obtained in this manner.
Dividing Head—A fitting which has provision for locking a spindle in a number of positions, representing divisions of the circle; used for tooling polygonal objects and for cutting gears on the milling machine. Also termed *index centres*.
Division Plate—A disc fitted to a lathe-head, or a dividing head. It has several circles of holes to effect divisions around a circle.
Dog Chuck—A chuck with jaws moving in slots.
Double—This prefix is placed before many types of machines having double heads or spindles, etc., or possessing double-acting mechanism to increase output.
Drifting—Finishing out holes of square or other shape with a drift, having serrations, or teeth, forced through the holes by power.
Drill—A tool which originates holes; flat, fluted and twist-drills are the principal.
Drill Chuck—A small chuck with long jaws operated concentrically.
Drilling Machines—May be of vertical or horizontal designs, with one or more spindles, provision for angling, hand or power feeds.
Duplex—This is a term applied to machines when portions are duplicated, as duplex rests.

EDGE MILL—A milling cutter that acts by teeth on its sides. Called also a *side mill*.
Elliptic Chuck—A special lathe chuck possessing a sliding portion, by which elliptical objects are turned or bored. Erroneously called *oval chuck*.
End Mill—A milling cutter operating by its end teeth, as distinct from an *edge mill*.
Ending Machine—The same as a *rotary planer*; employed for trimming the ends of large girders and columns, etc.
Engine Lathe—One of complete type, for sliding, surfacing, and screw-cutting.

FACE LATHE—One that has no poppet, work being held on the plate or chuck only.
Face Mill—An *end mill*, but of large diameter.

Face Plate—The disc screwed on the lathe spindle nose, and slotted to receive holding-down bolts.

Facing Arm—This is an attachment to a boring bar, by which the end portions of bored work are faced across.

Feed Mechanisms—Devices employed to feed slides or spindles at definite rates. Belt-cones or gears or friction wheels are used to effect the necessary changes.

Fixture—An appliance for setting and holding a piece of work on a machine in a definite position, which may be repeated exactly for other similar pieces. *Jig* is another name. Some, as for drilling, have guide bushes to control the position of the drills.

Flexible Shaft—Used in connection with portable machine tools, driving them in any position by the flexibility of the shaft, which is produced by coiled wires or a number of joints.

Floor Plate—A large tee-slotted plate on which massive work is laid and tooled by portable machines shifted about, and bolted anywhere on the plate.

Forge Lathe—A massive lathe employed for turning forged work, as shafts, etc.

Forming—Turning irregularly-shaped pieces with tools of the same profile.

Frame-plate Slotting Machine—This is a special type for locomotive work, having several slotting heads above a long table on which a pile of frame-plates are laid.

Friction-clutch—Employed extensively in machine-tool work, both for countershafts and in machine construction, for throwing movements in and out quickly.

GANG—Applied to a set of tools, such as gang mills, which are built up of several separate cutters.

Gap Lathe—A lathe with a break in the bed to receive large objects.

Gear-cutting Machines—These employ either rotary cutters or reciprocating planer tools. Teeth are pitched out with dividing wheels, or worm wheels. Machines are semi or entirely automatic. Teeth derive their shape from the cutters, or from formers or templets, or are generated by the mechanism embodied in the machine.

Grinding Machines—Those employing rotating wheels, and used for finishing plane surfaces, curves, holes, and cylindrical portions. Either the work or the wheel may move, or both.

Grinding Wheels—Wheels of emery, corundum, carborundum, or alundum, used in grinding machines.

Gun Lathe—A very heavy type for turning and boring guns. Steady rests are employed to support the great weight.

HACK-SAW MACHINE—A reciprocating type, carrying an ordinary blade; it has a vice to hold work.

Hand—Applied to hand-operated mechanisms, as hand-drill, hand-feed, hand-lathe (one with plain slide-rest).

Headstock—The driving head of a lathe or grinder. Also called the *live head, fixed poppet head, or fast headstock.*

High-Speed—Relates to the abnormal speeds possible by the use of high-speed steels. Lathes and other machines are much modified in driving and feeding details and strength of parts.

Hob—A short screw which guides the nut in a chasing lathe. Also a cutter for producing worm-wheels. A master tap over which screwing dies are cut.

Hobbing—Cutting worm and spur gear teeth by a rotating hob, the gear blank rotating continuously.

Hollow Drill—Made so in order to pump oil through to the cutting point and wash out the chips.

Hollow Mill—A hollow cutter which passes over a bar and reduces its diameter; usually held in a turret.

Hollow-spindle Lathe—One with a hole bored right through the spindle, to pass bars, which are turned and cut off. Spring chucks are placed on the nose.

Horizontal—A prefix used in connection with drilling, boring, and milling machines which have their spindles lying horizontally.

INDEPENDENT CHUCK—A chuck, the jaws of which can be moved independently of each other.

Indicator—An instrument which magnifies error in machine movements and enables delicate tests to be made.

KEYSEATER, or KEYWAY CUTTING MACHINE—An adaptation of the slotting machine, for cutting keyways in wheel-bores. It has a reciprocating tool.

LAPPING MACHINE—A kind of lathe which revolves a lap, charged with abrasive powder; used for truing out holes.

Lathe—A machine which rotates work upon a plate or chuck, or between two centres, and cuts with turning tools.

Lead Screw or Leading or Guide Screw—The master screw of a lathe, by which threads of various pitches are produced.

Line Shafting—The main shafting driven by the prime mover, and from which countershafts are belted.

MACHINE VICE—A vice with movable jaw, to hold pieces of work for tooling.

Magazine Feed—A mechanism which feeds separate pieces of work into a machine, instead of employing an attendant.

Mandrel—The spindle of a lathe-head. Also a separate spindle on which work is held for tooling. A mandrel press is used for forcing work on and off.

Milling Machine—One which employs rotary many-toothed cutters.

Multiple-spindle Drilling Machine—One with several spindles to drill a number of holes simultaneously.

NEST GEAR—A set of toothed gears mounted in such a manner that changes of speed can be obtained by different combinations.

Nut Lathe—Used for facing and chamfering nuts, held on a mandrel.

Nut-tapping Machine—A machine using long taps, which pass through the nuts until a string of them is done.

OIL—Used for lubricating machine parts and cutting tools.

Open and Crossed Belts—A means of reversing the motion of a pulley.

Open-side Planer—A planer in which one standard is omitted, leaving space for large work to project over the table.

Open-spindle Lathe—A *hollow-spindle* type, with a large slot into which the operator's hand reaches.

PIT PLANER—A large style of planer, in which the housings and rail travel over work supported in a pit.

Planing Machine—A reciprocating type of machine, in which the work usually travels on a massive table under the tools; sometimes the tools move.

Poppet—The loose headstock of a lathe or grinder. Called also the *tailstock, footstock*, or *sliding head.*

Profiling Machine—A milling machine, the cutter slide of which is controlled by a form resembling the work outline.

Pump—Used for supplying oil or suds under pressure to cutting tools.

QUARTERING MACHINE—Employed for drilling the crank-pin holes at right angles in locomotive wheels after they are pressed on their axles.

Quick Return—The rapid backward motion of slides during the non-cutting stroke.

RADIAL DRILL—A drilling machine having a pivoted arm, enabling the drill to be moved about over the work.

Reamer—A fluted tool used to finish drilled holes.

Rotary Planer—A form of milling machine using a large face cutter with inserted teeth.

SADDLE—A sliding portion which carries other slides or rests.

Screwing Machine—Either a bolt-screwing machine or a pipe-threader.

Screw Machine—A type distinct from the above. It possesses turret and rest, and turns and cuts off the work.

Screw-milling Machine—A recent development by which screws are milled instead of being turned.

Sensitive Drill—A small type, the spindle of which is fed by hand lever.

Shaping Machine—A machine in which the tool is carried in a reciprocating ram passing over the work-table.

Side Planer—Resembles a shaper, but the head travels along the bed, taking a long cut on the end of work too big to go in the ordinary planer.

Slot-drilling Machine—Used for cutting keyways and cottar-holes by a revolving cutter, endlong motion producing a slot.

Slotting Machine—A vertical ram machine with horizontal table.

TAPPING MACHINE—This operates taps for nuts, etc. A sensitive device obviates breakages.

Tool Grinders—Include those for lathe and planer tools, cutter grinders, and drill grinders.

T-slot or Tee-slot—This special shape is employed to enable bolts to be slid into any position for clamping work on tables.

Tyre Lathe—Used for boring and turning railway wheel tyres.

UNIVERSAL—Used in connection with certain machines which embody very complete movements, as universal millers, universal grinders, distinguishing them from simple or "plain" machines.

Universal Joint—A pivoted joint employed to transmit motion to portions which are not stationary.

VALVE CHUCK—A lathe chuck having jaws by which a several-faced object may be turned successively into several positions for tooling.

Vertical—Applies to the position of spindles or rams, as in vertical drills and boring machines, vertical lathes or boring mills.

WALL—Used to denote wall-drilling machines, wall planers, etc., which are not self-sustaining.

Wheel Lathe—A special kind used in locomotive shops for boring and turning wheels.

STRAW & FANCY HAT SHAPES

Methods of Making Straw Shapes. Pressing and Finishing. Net Shapes. Lace and Chiffon Hats. Fancy Shapes for Summer Wear

By ANTOINETTE MEELBOOM

THE straw used for working up in hat, toque, or bonnet shapes is at the present time easily obtainable, and can be bought by the yard or the piece of 12 metres (equal to 13 yards). English straws are made in pieces of 12 yards, Italian and some of the expensive makes in pieces of 8 metres. Diagrams **84, 85, 86** show some different kinds of straw. Although made straw hats or bonnets can now be bought at very little cost, they are more likely to fit, be much lighter and more original in design, when they are worked up by hand.

There are several different methods. The one in general use at present by all first-class milliners is to work the straw over a wire shape [see page 4860]. This method is specially suitable for fancy or crinoline straws [**85, 86**], and is the only possible one for making up fancy and more difficult shapes.

Make the wire shape according to the style desired; if for a very fancy crinoline, lace, or a very open straw, cover it with net, chiffon or tulle, and stitch the plait to it. No covering is needed for a non-transparent straw [**84**]. For sewing use glazed cotton to match the straw, and a straw needle.

Pin the straw round the outside edge [**89**], stretching it slightly (if a wide one) along the upper side, making the join where the trimming is likely to hide it. Wirestitch it to the edge wire just below the edge of straw. If the straw is over 1 in. wide, cut it through and interlace the ends, keeping them in place by a few stitches. Some straws can be so joined as to be hardly visible.

When using narrow straw do not cut each round, but continue one into the next.

Notice whether the shape has a curved-up brim like the Napoleon shape or a drooping one like the mushroom. For the first, the plait is sewn on rather tightly, with the right side of straw underneath. The stitches are seen on the wrong side inside the brim.

For drooping brims, the right side of the straw is on the outside of the brim. The stitches will show underneath the brim.

Pin on the second row, and sew it to the first, using the straw stitch, keeping the long stitch on the wrong side, and slanting the little stitch back the way of the plaiting of the straw, which will prevent it being visible on the right side.

Continue pinning and stretching each row along the outer edge, and slightly contracting the inner edge of the previous row till the brim is covered. Hat brims wider in front and sides [**83**] will require gussets—that is, extra rows of straw inserted across the wider parts. Some brims may have three rows of straw at back and five or six along sides and fronts.

For the crown, start from centre of tip, keeping the straw exactly to shape [**88**]. Bind the end of the straw with cotton, turn it under, and sew the straw round and round from the inner edge, manipulating it with the left hand, and easing it sufficiently to allow it to lie flat. In wide straws this is a little troublesome at first, but it is a difficulty which is soon mastered. Each straw is stitched *underneath* the last one, the fancy edge always showing outside. Be careful not to get a fluted tip, which happens when the straw is "eased" too much. If stretched too tightly, the crown will bulge.

If the straw can be pressed, do not sew it to the wire, but make it separately; press it, and then sew it to the crown. Finish off the brim with another edge of straw along the outside edge, and in the case of some toque shapes line the inside brim for two or three rows, or all over. In this case, do not take the stitches through the outside, but slipstitch the straw to the wrong side of brim. The tip must be pressed before the sideband is begun unless it is a dome crown, when it is finished entirely, and afterwards pressed. When the tip is the right size, bend the plait in half; this forms the turnover for sideband; the half-width turned over will be the first row of it [**87**].

Sidebands. For straight sidebands, each row is simply stitched to the next in a straight line. If larger at the top than at the base, tighten each row of the straw towards the headline.

For sidebands larger at the base than at top ease on each row of straw towards the headline.

It is usual to make the crown and brim separately in this method of straw-working. By working the straw over a wire shape as the foundation it can be sewn in all kinds of fancy ways, and two or more different colours of straw used.

The curved-up brims of toques can be trimmed with leaves of straw [**80**], rounds of straw, lace insertion, or lace medallions edged with straw, and various other variations which would not be possible if a wire foundation were not used.

It is possible to work straw without a wire foundation, but this is only suitable for very firm makes [**84**]. Insert a wire the size of headline plus 2 in. (for very brittle straw sew it on), on the top inner edge of straw. Bend it so that the outer edge of plait lies flat on the table, and join as securely and neatly as possible, the wire edge making headline, and the flat edge the row of brim.

Most hat brims are wider in the front than the back, the extra width being obtained by gussets, which should be next sewn on. Mark the centre-front of the headline, keeping the join for centre-back; pin on a piece also with a wire inserted

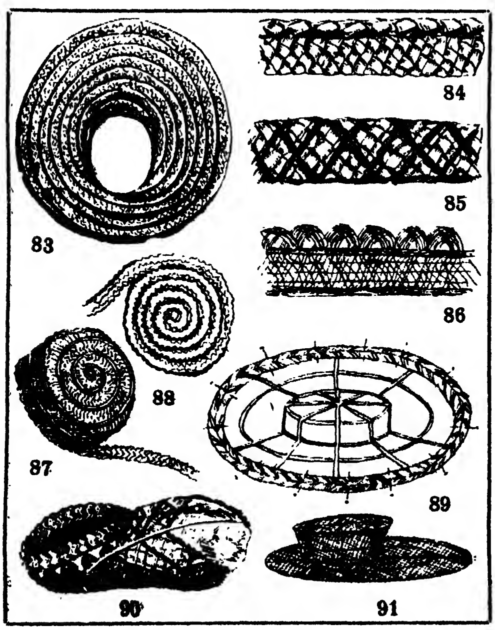
in the inner edge, graduating it to the sides. Repeat till the extra width is obtained. Then insert the wire, keeping it in one length, running it invisibly between the straw edges. Begin from the back, pinning and stitching it on to the gussets till the right size of brim is obtained.

Ease on the straw for fluted and crinkled brims; contract it for turned-up and for drooping brims. For flat brims, ease on the straw just sufficiently to allow each row to lie flat. Make the crown in the same way as before; the wire is not interlaced in the edge of straw unless it be for a very large flat crown, and in a few other exceptional cases.

Straws used to be made up over another hat brim of straw or buckram. If this method is required, pin the straw on to the shape, beginning from the outside edge. The straws may then be sewn together.

Firm, hard straws can be made entirely by hand, starting from the headline, one or two gussets inserted, and hat or toque finished off as explained. It must be wired round the edge. Four support wires laced in and out the straw are then inserted, leaving one end about an inch in hat and the other securely nipped round the outside edge. Finish with a row of straw to cover the edge wire, or line with a gauged chiffon, lace, or velvet lining, finishing the edge with the straw if desired.

Pressing. Only plain straw can be subjected to the process of pressing, as raised fancy edges would be quite flattened and spoiled. At the present time very few straws can be pressed. It is done in this way. Place the brim flat on the table, right side downwards, on an ironing blanket and cloth Place a damp cloth over it, and press with a warm iron.



83. Straw brim **84, 85,** and **86.** Three kinds of straw **87.** Shaping the sideband **88.** The tip **89.** Covering wire shape **90.** Straw toque **91.** Net shape

When nearly dry, remove the cloth, and finish drying it by placing the iron lightly over it. Some plaits are more stiffened than others, so discretion must be used as to the degree of dampness needed. Moisture will make the brim quite stiff and flat. Very limp strands are sometimes brushed over with gum arabic or white of egg.

Curved fancy shaped crowns are best ironed as the work is proceeding, as it is difficult to get the iron in the small curve when the shape is completed. Oval and dipped crowns of the boat-shape type are started with a piece of straw about 2 in. long, and the straw worked round it. Press it as soon as the dip is formed—it is impossible to get the iron in after the crown is finished. [92.]

Bonnets are made on exactly the same principle [94]. The front is worked first, leaving a piece of straw at one ear long enough to finish the back off neatly when the other part of the bonnet is finished. Cut off each straw at the back. The end of the straw left at the ear will finish it neatly. Make the crown separately, and sew it on.

Net Shapes. Hat shapes made in unglazed, French stiff net [91] are used for the foundation of chiffon, silk, linen, broderie anglaise, and mourning millinery. The glazed kind of net is not worth making up, as it loses its stiffness directly, leaving the net limp.

Cut the pattern in the same way as for an espatra shape, with the only difference that ¼-in. turnings are allowed on *all* the parts. Wire in the same manner, sewing the wire inside the turning along the edge of brim, and at the top of sideband. The turnings should be at the bottom of sideband. The ¼-in. turnings of tip come over the top edge of sideband, where they should be secured firmly just under the wire. Large shapes in net hats will require a second round wire, and some supports to keep the brim in shape. The supports are mulled or covered with narrow sarcenet ribbon. As few of these as possible should be used, as the wire is likely to show through the transparent trimmings. Mull all the edges in the same way as for espatra shapes.

Another method much used by good milliners is to make the wire shape and cover it with net cut to shape. Bonnet and toque brims are sometimes made of net, shaped and curved by pleating and casing the net, and afterwards wired.

For a lace hat make the wire shape and cover it with a single or double thickness of tulle or chiffon. Stretch the lace across the brim, with the front on the cross. Pin round hea line and edge. Cut the lace round the brim and crown, and allow small turnings. Wirestitch it to the headline and edge wire. Cover the tip in the same way.

Fit the lace round the sideband quite smoothly. Match the pattern, if possible, where the lace has to be joined. Quantity of lace required will be the diameter of the widest part of the brim, plus ¼ yd. for large crowns.

If both the upper and under brim are covered

with lace, twice the diameter plus ½ yd. to ⅝ yd. for crown—according to size—will determine the quantity needed. Guipure, and Irish lace look well with the edge of brim bound with velvet or fur; or the upper brim and crown can be trimmed with medallions of lace edged with narrow Valenciennes or ruchings of pleated tulle.

Picture hats are usually large hats of the Gainsborough, Rembrandt, or Amazon type, with tam-o'-shanter, low, high, or jam-pot shaped crowns. They are made of lace, net, tulle, chiffon [93], crinoline, or velvet. All but those to be covered with velvet, which have an espatra foundation, have their foundation shape made of wire, covered with net, chiffon, or tulle. Occasionally the whole shape is covered with tulle quillings. Handsome feathers are their chief trimming, and they are worn with or without tulle strings.

Picture Hats. For chiffon hats make a wire shape, and cover it with one or two thicknesses of chiffon. Mull the edge and bind with velvet or double chiffon. Cut the chiffon into 2½-in. strips on the cross, and join; or use the chiffon double, and run the edges together. Sew the first chiffon fold even with the brim, and let the next rows overlap nearly half-way.

For the sideband, work from headline upwards. Cover the top of crown, starting from the outside edge, and working round and round to the centre.

Lace medallions, or motifs, make a pretty finish, and an écru shade of lace on a black hat relieves what may otherwise be unbecoming.

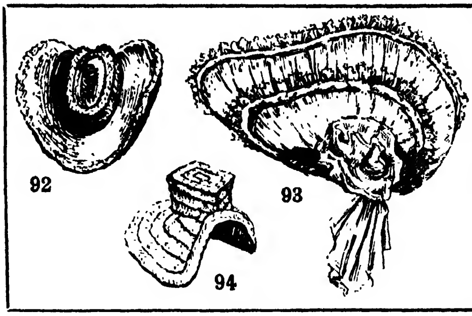
Rows of transparent lace, fancy chenille or crinoline inserted between the folds look well.

For fancy chiffon hats, make a wire shape, and cover it with double chiffon. Cover it plainly with printed or embroidered chiffon of a small simple pattern, such as bunches of pink roses on a white ground. Line the under brim plainly or with gauged chiffon. Edge it with narrow Valenciennes, and sew another row half an inch from edge underneath. Cut out the upper brim again, allowing 1 in. turning. Make a narrow hem round the edge, on which should be sewn narrow black, white, or écru Valenciennes lace.

Make a large round to cover the crown, hem round and edge with narrow Valenciennes lace. Sew in a bandeau. Trim the hat with soft satin ribbon, making a bow at the side, and another on the bandeau. For this hat, ¾ yd. of double-width printed chiffon, 12 yd. narrow Valenciennes lace, 3½ yd. of 7-in. wide satin ribbon are required.

Motor Hats. For motoring, shapes can be made with a round brim, or a peak in front, of the mushroom shape, with eight-gored crown. Where stiffness is required for the interlining of brim, peak, or band for headline, use firm canvas or double stiff net. Wire as for shape-making. Interline the crown with canvas or quilted linen.

Linen hats are made of double stiff net, cut to shape, and wired round the edge and once in centre brim. Cover top and bottom of brim with linen, tack and machine-stitch round edge once or thrice. Finish crown in the



92. Straw boat shape 93. Chiffon hat 94 Straw bonnet

same way and trim plainly with a ruching made of ribbon or crossway silk, or any other simple trimming that may be preferred.

Fancy Shapes. Garden party, river hats, etc., are made of light material and fancifully trimmed. They have a wire foundation covered with two thicknesses of tulle or Brussels net. The edge of the brim is covered with velvet or quillings of lace. The shape may be covered with narrow Valenciennes lace (eased while being sewn on), petals of flowers, medallions of lace, broderie anglaise edged with narrow Valenciennes lace, or net, or tulle quillings. The brim between the medallions may be covered with lace or fine crinoline straw. Ninon silk muslin, accordion-pleated silk may be used, or batiste, edged with lace, baby ribbon, or narrow straw; and there are still an infinite variety of other methods of treatment. These hats must be lightly trimmed.

Drawn silk bonnets may be made of taffetas velours silk, net, chiffon, or chiffon velours. First obtain a pattern shape to work over. Put the support wires on the shape, turning them over the edge to keep them in position. Fix firmly where they cross each other. To cut the material for bonnet, measure length from ear to ear, and allow twice or three times as much for fulness. Then measure width from centre-front of brim to centre of crown, allowing ½ in. extra for each casing. Mark centre-front, and run a casing for outside edge. Decide the position of round wires, and run casings to correspond, measuring distance at centre-front and at ears, also at an intermediate distance if necessary. Push in the wires, making the outside wire long enough to go round the back and wrap over two inches. Pin net or silk on shape, centre-front to centre-front, the silk to reach the ears only. Fix outside wire round back. Draw up each casing in turn to required size, and fix wires to outside wire. Regulate the fulness carefully and secure threads. Nip each support wire in turn over the outside wire; when the last one is thus fixed, the pattern shape will come freely away. Fix the round wires to support wires, and tie them firmly and invisibly wherever they cross. Cut away any superfluous silk in centre of crown, turn it in, and finish the crown off neatly. Bind the back of the bonnet with a piece of silk, velvet, or net, and trim it with velvet, flowers, passementerie, tips, or any light trimming.

Continued

CYCLOPÆDIA OF SHOPKEEPING

SHIP CHANDLERS. The Ship Chandler's Shop. Departments. Details of Stock. Varieties of Trade. Profits

SILK MERCERS. The Necessary Experience. A "West-End" Trade. Stock and Profits. Silk as a Side Line

SILVER AND ELECTRO-PLATE DEALERS Buying and Care of Silver. Licences. Qualities of Electro-plate. Profits

SHIP CHANDLERS

In many seaport towns, usually in premises abutting the quays, or hidden away in small streets running off the water's edge, there may be found shops in which the grocer, the baker, and candlestick maker seem to unite in one personality. Ship chandlery is the comprehensive term applied to the stock of the proprietor whose business is to supply the wants of seafarers. If the port is frequented only by sailors who never get beyond the beams of the "Coastwise Lights of England," the nature of the stock will most probably consist of comestibles, but if the harbour is one where ocean-going vessels put in there will be one, at least, important shop where a great variety of stores can be obtained.

The business is one in which some experience at first hand is desirable if success is to be won, but there seems no reason why an enterprising ironmonger, or a grocer with ambitions not bounded by butter-kegs and sugar-boxes, should not engage in it. We recommend those who contemplate such an enterprise to read the articles beginning on pages 3041 and 3572.

The Shop and Fixtures. A big rent is not essential for this business. Ship chandlery implies trading between man and man, and convenience rather than style is to be sought. A shop with a good depth, a fair-sized window and a big doorway would meet the case. The depth is necessary to allow for a big display inside, where a survey on the part of the purchaser is likely to remind him of this or that article not on the list in his hand. A comparatively small window should suffice because the stock—except in the lamp department—does not lend itself to effective display. We think the big doorway will need little comment. It is inviting, and if the side is used to display tackle, lamps, blocks, ropes, etc., it is fairly certain to tempt the passing skipper, or his steward, purser or cook, to stop and examine the wares.

The fixtures on the provision side will be like those of a grocer's shop; in the hardware department, about half the available shelves may be divided like those in an ironmonger's store, the rest being somewhat deeper from back to front, and higher between the shelves. The reason for these differences is to be found in the fact that a fair proportion of the stock is not kept in parcels. Such articles as cleats, chocks, blocks, thimbles, and the like, are galvanised and kept strung on cords, the bundles being placed in the fixtures in full view of the customers.

From the ceiling, and possibly from one wall, half-inch iron tubes should be fixed in hangers or brackets, these being provided with S hooks for receiving wares which lend themselves to hanging up for display or storage. A substantial counter with plenty of good deep drawers in it is necessary, but the ship chandler need not worry about show-cases, brass rails, window fittings in bronze, and other expensive accessories.

The Stock. The proprietor of a business such as we are describing will have to possess, or acquire, a sound knowledge of market grooves somewhat out of the ordinary. Any sum between three or four hundred and as many thousand pounds might be invested easily, and, opportunity being proportionate, profitably. Some of the stock—that which represents the requirements of every single trip a ship makes—will be turned over six or eight times in a year, whereas the capital locked up in other departments may not be moved more than once or twice. The profits on the former class will have to be cut nearly as fine as those on grocery and provisions for home consumption. On the latter they should show margins equal to those mentioned in the article on ironmongery [page 3572], and possibly even a little more if local competition be not too keen.

Departments. Although the stock will be kept under one roof, and more or less mixed, it is useful for our purpose to classify it. First there will be the food stores, including packed food, ships' biscuits, flour, yeast, spirits, soap, candles, oil, brushes, and the hundred and one items which are necessary for feeding the passengers and crew and for maintaining the comfort of the boat at the standard permitted or prescribed by the owners. This is the department which must be visited every time a ship puts into port. It will be the mainstay of the small concern, and therefore must be kept to the front. Next to it in importance will be the stock of small marine hardware. Here we should expect to find shipping tackle in wrought and malleable cast iron (galvanised), brass, bronze, and wood. Here are just a few of the many lines which might be carried: Blocks (a single list before us enumerates thirty distinct types, and shows hundreds of patterns which do not include the common elm pattern with lignum-vitæ sheaves), gaff, boom, and other bands, chains, cleats, bushings, deck lights, hinges, and fastenings, hooks (nearly 40 sorts), nails, mast fittings, rowlocks, sheaves, shackles, thimbles, swivels, and turnbuckles, or straining screws.

The foregoing, with wire, rope, and hemp cordage, constitute quite common stock, and as the business expands room will have to be found for anchors, ships' bells, cooking and heating apparatus (the latter sometimes including steam radiators), pumps, steering gear, capstans, windlasses, etc.

Lamps. Lamps cannot be neglected. The stock to be seen in a well-equipped business includes side, anchor, and masthead signal lamps, some of them listing up to £5 and £6 per pair. These are made with copper bodies and fitted with what are known as *dioptric* lenses. Among smaller lamps mention may be made of those found in the engine-room, gimball lamps for the cabins, and cargo lamps for the holds. From the sources where these are procured, the ship chandler can draw such goods as fog-horns, speaking-trumpets,

megaphones, oil-feeders, water-dippers, forecastle and bunker lamps, fillers, measures and funnels for oil and other liquids. A demand for a certain class of lamp-glass ware for replacement may be expected, and tools for shipwrights and sailmakers should not be overlooked in making up the schedule of stock required for a start. To the tools usually required by a carpenter must be added such special forms as caulking and crease irons, scrapers, marline-spikes, sheathing hammers, caulking mallets, sail hooks and prickers, and sailors' palms and needles.

Naval Brass Foundry. Under this head a few lines may be devoted to the consideration of fittings in brass or bronze which are specially likely to be in demand in yachting centres where some pretensions to style are maintained aboard. This class of stock will include strap, hook, and plain hinges, hasps, port lights, ventilators, deck lights, ships' bells from 6 in. diameter up to possibly 20 in., name-plates, cleats, curved and fair leads, rowlocks, straining screws, boathooks, step nosings and plates, hand and cabin rails, and brackets, not to mention scores of other items of general brass foundry. So important is this department that it pays to cultivate a trade in repair work to pattern, and special parts for replacing in case of breakdowns. To run such a section profitably it is necessary to be in touch with a brassfounder who can guarantee prompt and special attention to shipping orders without regard to their intrinsic value. It is often a matter of great importance that a replacement should be obtainable within a strictly limited time, and there is small consolation for the shopkeeper who receives an expensive fitting an hour after a boat has sailed. Much the same remark applies to the galvanised ironwork. A contract with a firm who do galvanising for the jobbing trade may end in so much business that way as to warrant, in due course, your chandler in putting down his own "pot." In that case there would be other opportunities for making profits.

In towns where steam-boats and packets put in, such stores as boiler mountings, lubricators, tube brushes and scrapers, shovels, files, engineers' tools, lubricating oils, cotton-waste, and engine wipers find ready sales, and, on the East Coast at any rate, fishing tackle would have to be handled.

As a business grows in importance, the proprietor may expect to be consulted about charts and instruments for navigation, but before that comes to pass there ought to have grown up a call for lifebuoys, compasses, and bunting.

Working Department. Sooner or later a successful ship chandler has to face the question of a workshop staff. Unless he is prepared to neglect possible sources of profit he must have a smithy, with a clever, resourceful man at the forge as well as a competent coppersmith. Besides, there will be opportunities of fixing cooking apparatus, filtering systems, sanitary equipments, not to mention jobbing work for machine men and fitters in connection with engine repairs and pump parts. Sufficient work to keep a forge, a lathe, and a drilling machine busy may be confidently looked for if the plan is adopted of boarding every boat that puts into port, with a view to soliciting orders for stores and work.

Terms of Business. Something about profits has been already written. As a fair percentage of the turnover is likely to be for cash against sailing, list prices are not uniformly obtained. In pleasure resorts, however, full prices for cash are sometimes obtained from wealthy owners of yachts, the one thing demanded being a prompt service. As, however, these list price sales not infrequently cover a telegram and carriage from works, the gilt is apt to be rubbed off the gingerbread.

Ship chandlery, however, is not all done on a cash basis. Seafaring folk are no better off than many landsmen, and credit has to be given just as is the custom in an inland town, and with about equal risk of making bad debts. Fleet-owning companies usually have their own chandlery stores, and buy direct from the sources open to the chandler; but when a retailer does get a foothold with such a company, he has to give the usual terms, monthly or quarterly accounts, subject to prearranged discounts. Owners of smaller vessels, who run their own coast-bound craft, may expect to pay on the return trip basis. Whether that plan is safe and profitable is a matter which has to be decided in every case on the standing of the owner or his representative.

SILK MERCERS

There was a time when the silk mercer was one of the richest and busiest of shopkeepers. In London the neighbourhood of Ludgate Hill was his habitat, and the country squire or well-to-do farmer visiting the metropolis invariably called on him, and took back as a present to his lady twenty yards or so of silk for a dress. The business was an important and flourishing one even up to fifteen or twenty years ago, for then every lady had at least one rich black silk dress—"one that could stand by itself"—as an indispensable article of her wardrobe. But times have changed, and the modern silk mercer, doing a retail business in silks and velvets solely, is now seldom to be met with. The large drapery stores, with their silk departments, and the rage for the less expensive silks, are mainly responsible for this. In the old days 10s. to 12s., and even 15s. to 18s., per yard was by no means an unusual price to pay for silk, while nowadays 1s. to 10s. 6d. for good qualities is considered quite enough. But there is no reason why, even in these unregenerate days, and in spite of the rage for cheapness, a man with the requisite experience, taste, and, above all capital, should not make retail silk mercery an extremely profitable outlet for his energies and capital.

Experience and Other Requisites. In the warehouse of a wholesale dealer in silks the necessary experience may be gained. Silks and velvets go together, so that the youth whose father or friends can ensure a capital running into at least four figures would get to know the business in such an establishment. If possible, he should endeavour to go for a year or so to some of the large manufactories in Lyons, Zurich, or Como, so that he may be taught the making of silks from the beginning, the varieties, and the prime costs. There are several manufacturers in England who, of late years, have been producing silks more suitable than formerly for the home market. The youth could get good experience in such factories without going abroad. Such experience is, however, only for the privileged few, and would be out of the reach of most aspiring silk mercers. But they need not be discouraged. The majority of the successful silk mercers of to-day were drapers first and silk mercers afterwards. A very thorough training may be obtained in the silk department of a large drapery business, and provided the youth has the necessary taste and liking for this, the highest grade of the drapery business, there is no reason why he should not succeed. In fact, the usual evolution of the silk mercer is by rising from the ranks in drapery

to the position of silk buyer in a large drapery business, and so on to business on his own account. We will endeavour to treat the subject, first, from the standpoint of the man who wishes to retail silks and velvets only on his own account, and secondly, silk mercery as a department of drapery.

The Money Required. The articles sold may be classed as luxuries, therefore a first-class neighbourhood must be chosen for opening. The question of capital is therefore all-important, for not only must the establishment itself be fitted up in first-class style, but the goods sold are expensive. It might be possible for a man who knows the silk and velvet trade intimately, and who in buying for a large drapery house for years has gained the confidence of the manufacturers, to begin on a capital of from £1,000 to £2,000. But it must be distinctly understood that unless he is sure of the backing of manufacturers in the way of extended credits, such a sum is not a safe one. When a young, energetic man has been the buyer for the silk department of some well-known drapery house for some years, and has demonstrated his capability and business aptitude by making the department—an extremely "tricky" one, always—a success, he may gain the confidence of the silk merchants and manufacturers with whom he has come in contact so that the sum mentioned may serve; for then there is a possibility of obtaining a certain class of goods on sale or return, and easy payments may be arranged. But it is desirable that at least £4,000 should be forthcoming before a start is made, and then the manufacturer will be the beginner's good friend.

The West End Establishment. With the capital named, the shop selected would be a small one in the best neighbourhood. Let us take the West End of London as an example, and assume that a suitable shop with one window is chosen in a locality like Oxford Street. The rent would not be less than £500 a year, and the fittings would cost about £300. The ideal fittings would be in light oak, plain, substantial, and good. On one side of the interior a plain wall fitting with "silk fixtures" would be erected. The "silk shelves" are specially made, shallower than the usual drapery fixtures, and the requisite length (22 in. to 24 in.) to take a piece of silk. The fixtures could be made to come well out from the wall, and may be provided with false backs to give an appearance of fulness. On these shelves are placed velvet-boxes for stock, either millboard covered with green linen, or preferably the boxes might be of imitation light oak to match the fittings. At first a set of dummy boxes might be employed, for it can scarcely be expected that the beginner would fill up his shop with stock even if he had the necessary capital. On the opposite side to the shelving silk show tables should be placed. These are narrow tables, and from the tables to the ceiling there would be mirrors with brass brackets fixed here and there, from which the varieties of silk are draped in neat and effective folds. Such a device serves the double purpose of displaying the goods to the best advantage and of making the most of a small stock. Plain but handsome chairs of light oak, a plain counter of the same material, and imitation parquette (linoleum) in light oak squares for the floor, would complete a charming interior. The window interior should be fitted with mirrors up the sides and perhaps half-way up the back, and a few brass brackets and brass stands (these not costing more than £5 all told) for displaying the goods. Although electricity is preferable for lighting, the shop should be heated (with gas or otherwise), in order to keep the goods in prime condition. The cost of fitting and wiring a small shop (including two outside lamps over the window) should not exceed £20.

Buying. The cautious man would be careful to select mainly silks of the plainer sort for a start, and a few expensive brocades and fancy goods in short lengths for display. The fashions being so fickle, it is next to impossible to advise what particular kind of material to stock. The alert man would know what was to be the fashion of the season, and buy accordingly. He would (assuming a £4,000 capital) lay out about £2,000 on an opening stock, buying only "safe" sales, and taking every precaution that foresight and experience has taught him to buy the "right thing." There are plenty of wholesalers in London from whom he may buy, but there can be no doubt that the man who can go to Lyons, Zurich, or Paris has better chances, seeing he buys at first hand. He has more frequently the advantage of bargains and longer discounts. In Lyons, silks are sold either by the metre or by the aune (115 centimetres); in Paris usually by the metre. The usual credit, buying from the manufacturers or manufacturers' agents on the London market, is 1¼ per cent. discount for 30 days. Buying from the wholesale houses the discount is 2½ per cent. for four months. The practice in Lyons, if one can secure the "long discount," is "13 per cent. and 2 per cent"; in Zurich it is 1¼ per cent. for 30 days. The experienced man knows well the advantage of such discounts, and there is little trouble in calculating the price per yard. One aune equals 1·15 metres, or 1¼ yards. Buying with long discount at Lyons, silk costing about 2 fr. per aune would, with the discount off, come out at about 1s. 1d. per yard on the English counter; a cost of 3 fr. 60 per aune would mean 1s. 11½d. per yard net, and so on. In Paris, on the other hand, 5 per cent. is the usual discount, and goods costing 2 fr. per metre would mean a net cost of 1s. 4¾d. per yard in London, while 3 fr. 60 per metre would come out at 2s. 6d. per yard. There are many agents for the cheaper silks and velveteens in London, or the buyer may go for these to the Manchester manufacturers direct. The terms in this country are practically those which prevail in the drapery trade [see page 2221].

What Is Bought. So much depends, as has been said, on the unaccountable vagaries of fashion that the judgment of the buyer and an exact knowledge of what is going on in fashionable dressmaking and millinery circles are essential in choosing an open stock. Velvets may be a rage at the period our beginner intends to start. It will be his business, therefore, to choose with taste and discrimination the correct shades and qualities in black and coloured silks and in velvets. If coloured silks have a vogue, an assortment of fancy moire antique, moire velours, taffetas, broché, surahs (checked and striped), mervs, shot glacés, plain foundations, satins (plain or fancy brocaded), may probably be the proper goods to choose. Silks for trimming dresses or hats are often necessary, and for these a considerable variety of shades must be secured. Black silks are nearly always in request, Bonnet et Cie, and Tresca, of Lyons, being the noted makers. The "latest" designs in moire velours, moire antique dama, moire cotelée, striped moire, black broché, black faille Francais, bengaline, Irish poplins, and black Duchesse satin may be the season's requisites. But in starting it is not a bad plan to make one class of silk—such as Japanese silk, for instance—a

speciality, and to "run it" in a good long range of the choicest colours. There are always many specialities in silks and satins for evening wear and for bridal gowns to be thought of. A judicious selection of whatever is the correct thing for the season having been obtained, the pieces should be laid longways in the fixtures. The proper way to store silk is, of course, end on, but the beginner's stock would not be large enough at first to admit of this without giving a somewhat empty appearance to the shop. There are velveteens of different colours also that may be bought in boxes of 20-yard lengths. These are the things to make specialities. A low-priced silk or velveteen costing probably 1s. 8d. to 1s. 9d. per yard will sell readily, if the shade and appearance is right, at 2s. 6d. per yard. There are, besides, English silks retailing at 1s. to 1s. 6d. per yard that would have to be kept nowadays, and Japanese silks, dyed all colours, have a quick sale. These may cost anything from 8½d. to 1s. per yard, and will sell well at 1s. to 1s 6d. Although it is considered somewhat out of the province of the pure silk mercer, there is no reason why made-up silk blouses and silk skirts should not be kept in stock. These are in no wise out of place, and the modern craze is for made-up goods.

Assistance. It would be necessary to have at least one assistant (£40 a year, indoors), unless the beginner resolved to work the business with an apprentice only to help him. An apprentice would serve three years, receiving no salary, but he would be useful in many ways, such as cleaning the inside of the windows and doing the general dusting. At first the outside window-cleaner might also serve as porter and message boy, for a regular messenger is not usually necessary in a small business. Great care must be taken in measuring the silk for sale, as a few inches wrong makes a great difference in the profits, and the goods are expensive. The assistant should, therefore, be looked after until his exactitude in this respect is established, and the apprentice needs careful training. Silks are usually measured by the fold.

The Silk Department. As an adjunct to a regular drapery house, the establishment of a silk department is, of course, much easier to accomplish than an independent start, for the draper's credit is established beforehand with the manufacturers and wholesale houses; moreover, his customers are already secured. All that is necessary to develop the business is to lay out from £1,000 to £1,500 in a silk stock on the lines that have already been indicated. Occasionally the thriving draper may, by arrangement, secure a large consignment of silks for show purposes, on sale or return. But the same care must be exercised if the department is to be made to pay, although the draper has greater advantages in being able to employ silk remnants directly in the millinery and dressmaking departments of the house.

Looking for Business. Reverting to the pure silk mercer, it is necessary that he should endeavour to increase his sales by cultivating the fashionable dressmakers and milliners. These ladies should be assiduously looked after, as opportunity occurs, not only in order to sell them silk for dress-pieces, but also silk linings of all kinds, largely used nowadays for good dresses, coats, mantles, etc., little lengths of velvet and coloured silks for trimmings for hats, dresses, etc., and things of that sort. The draper with a silk department has an outlet for these oddments in other parts of the house, but the silk mercer has to look for somewhere to plant the "scraps," which are by no means inconsiderable, and all of which mean money.

The All-important Question. Providing that the young man is a keen buyer, and buys what will sell, his profits should be considerable. The stock is heavy, and ought to be turned over at least three times a year; therefore he must have a profit of at least 33⅓ per cent. on the turnover in plain goods, and 45 per cent. to 50 per cent. on fancy goods. Good plain silk costing 3s. 6d. to 3s. 9d. per yard will sell readily at 5s. 6d. to 6s. 6d. per yard. It is no uncommon thing for a buyer who knows his market, and who is able to buy in fair quantity, to pay 4s. 1d. to 4s. 3d. per yard for a certain class of superior stuff for which the customer will pay 6s. 6d. to 8s. 6d. per yard, and think she is getting a bargain. But the cheaper silks, although they bear a smaller profit, have the recompense of a considerably quicker sale, and they bring customers to the establishment whose taste in silk it might be possible to educate to a higher standard—of profit.

SILVER AND ELECTRO-PLATE DEALERS

It would be folly to open a shop for the sale of only silver and electro-plate without considerable capital. True, there are such shops, but they are few in number and old-established, with a connection that has taken years to build, and are found only in the heart of our largest and wealthiest cities. Therefore, we shall consider the business as allied to that of a jeweller.

The jeweller is sure to know something about silver and electro-plate ware, and whether his district justifies him in adding the silver department, provided he has the necessary capital.

Opening Shop. The aspirant to a new business will find, under Jewellers [page 3732], hints regarding the selection of the site, on the basis of a £500 capital. An additional £200 to £250 is necessary if the silver branch be undertaken as well. The preliminary expenses are largely in fitting up the necessary show-cases. We advise the purchase of good-fitting cases, the essential quality of which is air-tightness, which means being practically dust-proof. Dust soils silver and electro-plate, hence the need of dealing only with experts in that branch of cabinet-making. But you may by chance get hold of some good secondhand cases; but if unable to procure uniformity in design and colour, it is well to purchase new cases, as uniformity or harmony is essential, and alterations are expensive. The distinguishing characteristic in cases should be brightness—in other words, as much glass as possible, including mirror backs, and on no account should wooden shelves be used. The cost of a case will vary according to size, design, and the wood used. Leave ebony colour alone. Ebony in itself is expensive, and its colour is depressing. The minimum cost for good cases will be about £30 each. Two or three will be required for an attractive display. Fittings will probably run into about £100, and £150 will be left for stock. In business as a jeweller, the retailer should have no difficulty in getting the usual terms from the wholesale houses, varying from one to three months' credit, with different discounts. Some firms give 5 per cent. for cash in one month, 2½ per cent. in two months, and net at three months; others give 2½ per cent. at one month only. The beginner will likely have to pay something down, unless he is known in the trade.

Stock. The purchase of stock requires careful consideration. The nature of the district must be considered, the class and quality of the goods likely to be in demand, whether useful, or ornamental, or both. Most retailers stock both classes, but preference in quantity is given to the useful. It is presumed that our retailer has some practical knowledge of the trade technicalities, such as the difference between silver and base metals, when the latter is plated with silver. On a manufactured article there is always the hall-mark, and the public demand it, the only exception being on copies of antique silver work. The hall-mark for Great Britain is a "lion passant"; on Continental and American manufacture is stamped the word "Sterling."

Silver. Silver is used in two forms—solid, and made into articles of itself, or deposited through the process of electro-plating on base metals, such as "Nickel silver," sometimes called "German silver," and on Britannia metal, known in the trade as "Pewter." The difference in the two base metals can be detected by sound, by giving the article a slight tap; the "nickel silver" will give a bell-like ring, whereas the "pewter" gives only a dull thud. The latter is also very soft, and more easily worked: it therefore constitutes the cheapest material sold as electro-plated ware, and receives only one coat of silver deposit. All the articles of better quality are made in "nickel silver," plated with one, two, or three coats of silver, technically termed "plated," "A quality," and "A1 quality." The article with the one coating has more often stamped upon it the two letters "E.P." Some firms use the letters A, B, and C, C denoting the poorest quality. The first quality is usually applied to table ware, spoons, forks, etc., as these are subject to the greatest amount of wear.

The nucleus of the stock should be carefully selected, and several houses must be visited in making the selection. Certain firms confine themselves to certain articles. Again, even in the same article, houses may vary a little in price. But there is quality and finish to be considered. What may look alike in two different windows will occasionally look totally different when under close inspection.

The jeweller should confine himself principally to the silver and better quality of electro-plate. People look to the jeweller's shop as a guarantee for quality. Of course, in some districts, the better quality would be rather expensive, so we repeat that from the new start the retailer must find out the nature of the demand in the district, erring on the side of caution. A good middle-class neighbourhood can be relied upon for articles of a quality that will stand wear and tear and yet keep their appearance.

The bulk of domestic items should be in silver-plate, on "nickel silver"—namely, tea sets, cruets, entrée dishes, butter and preserve dishes, trays and salvers, spoons and forks. But smaller articles, such as single salts, peppers, mustard-pots, sugar-sifters, butter-knives, preserve spoons, and afternoon tea-spoons, should be mostly in silver. There are side lines, both useful and ornamental, such as candlesticks, flower vases, serviette rings, inkstands, and separate ink-bottles, and toilet ware, which should be chiefly in silver. Owing to the present cheapness of silver, most little nick-nacks are made with it.

Where to Buy. Where to buy is a difficult question to answer. There are at the present so many manufacturers and wholesale houses that make and stock silver and electro-plated goods. The best trade paper is the "Watchmakers', Jewellers' and Silversmiths' Journal," and therein will be found the names of selling firms. The three leading centres are London, Sheffield, and Birmingham, in England; Glasgow, in Scotland, and, in a minor degree, Dublin, in Ireland. London manufacture, however, is usually the most expensive. As a rule, it is heavier and better finished, and the demand, of course, is principally in the West End of the metropolis. All advertisers invite retailers to send for catalogues, on receipt of business card. Once it is known in the trade that you are stocking silver goods, the ubiquitous commercials will not be long in calling. Remember that what may sell in one district does not always sell in another.

Stock-Keeping. Having gathered your stock, see that you take care of it, for nothing is more subject to the influence of the atmosphere, and more especially is it so in winter. Finger-marks ought to be removed at once by a chamois skin kept for the purpose. To be continually allowing silver to become oxidised or tarnished means a lot of work in renovating, and the freshness may be taken off in the process. Nothing looks more seedy and unattractive than dirty-looking silver. You not only lose the sale, but your reputation and profit will suffer.

It is only the expert who can get the mirror-like surface on silver, and the all-powerful medium is rouge. It is not a pleasant material with which to work, and in the hands of the novice there would be destruction through it in other ways. For instance, if it gets on to wood or cloth, it is difficult to get out; in fact, the more you rub it, or wash, the more it will spread. But there are many brands of plate-powder, of various qualities and degrees, but by sampling the best you can easily find out which is the most suitable. Always use a soft chamois skin; keep it clean, and only for the one purpose: the best result is thus obtainable.

Profits. Profit will vary according to the variety and quality of your goods. Photo frames are the least remunerative of all articles, and are, in fact, not worth stocking, although the jeweller must keep them. The retailer ought, if possible, to price on 50 per cent. profit, this high rate being necessary by reason of expenses, the detriment to stock through atmospheric influence, and having to sell at a big discount designs out of demand. Some firms issue priced catalogues, subject to 33⅓ per cent., which is equal to the above 50 per cent. on cost price.

We find that silver and electro-plate are sold by other branches of retail business, notably by ironmongers, drapers, stores, fancy-goods shops, and even chemists. The "pewter" article is chiefly found in the ironmonger or cutlery shops; the others, outside of the stores, generally confine themselves to silver nick-nacks, being able to do so, as they come under the exemption clause of the licence fee, which is, up to 5 dwt., free: above that weight, and up to 30 oz., £2 6s. per annum. Over that weight, unlimited, it is £5 16s. per annum. The licence is not much, but it is an item to be considered when competition is so keen. Under the nature of his business, the jeweller or silversmith is bound to possess one or the other of them. Those who carry only electro-plate are also exempt, which is somewhat of a hardship on the legitimate silversmith.

Continued

Continued from page 5088

ITALIAN

Continued from page 5082

By Francesco de Feo

PREPOSITIONS

Prepositions (from the Latin *præponere*, to place before) in Italian always precede the words they govern. They indicate a relation between two words, as: *Venite con noi*, Come with us. *Il libro è su la tàvola*, The book is on the table. *Vengo da Roma*, I come from Rome. *Una catena d'oro*, A gold chain.

Prepositions may be divided into Simple and Compound.

Simple prepositions are: *di*, of: *a*, to: *in*, in and into: *con*, with; *su*, on: *per*, for: *tra*, *fra*, among and between.

[See page 2045 for the prepositions *di*, *a*, *da*, *in*, *con*, *su*, *per* compounded with the article.]

Compound prepositions are: *accanto a*, beside: *dietro a*, behind; *dirimpetto a*, opposite to; *a cagione di*, on account of, etc. Many words are sometimes used as adverbs, and sometimes as prepositions. Examples: *sopra*, upstairs: *sopra la tàvola*, on the table. Many words which are real adjectives or parts of verbs are used also as prepositions. Examples: *durante*, during; *eccetto*, *tranne*, except; *nonostante*, notwithstanding; *lungo*, along; *mediante*, by means of, etc.

The preposition is invariable.

The prepositions most frequently used are:

contro, against	*avanti*, before (not of time)
dopo, after	*senza*, without
oltre, besides	*sotto*, under
fra, *tra*, among, between	

The above prepositions are sometimes followed by *di*, especially if they precede a personal pronoun. Examples: *Dopo di lei*, after you; *tra di noi*, among us; *senza di lui*, without him; *sotto di esso*, under it, etc.

Senza (*di*) also means "but for," as: *Senza di lui sarei morto*, But for him I should have been dead.

al di là di, on the other side of	*attorno a*, around
al di qua di, on this side of	*innanzi a*, *dinanzi a*, before
accanto a, near, by the side of	*riguardo a*, concerning
per mezzo di, by means of	*vicino* (vee-cheè-no) *a*, near
invece di, instead of	*per mancanza di*, for want of
ad onta di, in spite of	*a causa di*, on account of
lungi (loòn-dgee) *da*, far from	*insieme con*, together with
in fàccia a, in front of	*in quanto a*, as to
	fin da, since
	fino a, until

etc.

Sometimes two simple prepositions are used together, as: *da per me*, by myself; *al di là del fiume*, on the other side of the river. Prepositions are occasionally placed after their complement, when the complement consists of either (1) pronominal or adverbial particles united to the verb, or of (2) adverbs of place. Examples: *Gli si mise davanti = si mise davanti a lui*. He put himself before him. *Pensàteci su = pensate su ciò*, Think over it. *Qui vicino = vicino a questo luogo*, near here. *Là dentro — dentro quel luogo*, in there.

Exercise XLIX.

1. Lei non imparerà mai niente, perchè gioca sempre durante la lezione. 2. Invece di cento lire ne abbiamo ricevuto soltanto cinquanta. 3. La villa di cui le ho parlato si trova al di là del Tamigi. 4. Siamo stati obbligati di rimandare la partenza fino a lunedì per mancanza di danaro. 5. Se avete freddo sedete accanto al fuoco. 6. Dirimpetto a noi c' è una casa da fittare. 7. Badate, lì c' è il mio cappello; non vi ci sedete sopra. 8. Eccetto questi due, tutti gli altri quadri non vàlgono niente. 9 Parliàmoci chiaro, fra noi non ci dèvono èssere misteri. 10. Lo farò per amòr vostro. 11. Più di quaranta persone restàrono sepolte sotto le macèrie.

Esercìzio di Lettura

"In che posso ubbidirla?"[1] disse don Rodrigo, piantàndosi[2] in piedi nel mezzo della sala. Il suono delle parole era tale; ma il modo con cui eran proferite, voleva dir chiaramente: bada a chi sei davanti, pesa le parole, e sbrìgati.[3]

Per dar coràggio al nostro fra Cristóforo, non c' era mezzo più sicuro e più spedito, che prènderlo con maniera arrogante. Egli che stava sospeso,[4] cercando le parole, e facendo scòrrere tra le dita le avemarie della corona[5] che teneva a cìntola, come se in qualcheduna di quelle sperasse di trovare il suo esòrdio; a quel fare[6] di don Rodrigo si sentì sùbito venir sulle labbra più parole del bisogno. Ma pensando quanto importasse di non guastare i fatti suoi o, ciò ch' era assai più, i fatti altrui[7], corresse e temperò le frasi che gli si eran presentate alla mente, e disse, con guardinga umiltà: "Vengo a proporle un atto di giustizia, a pregarla d'una carità. Cert' uòmini di mal affare[8] hanno messo innanzi il nome di vossignoria illustrissima, per far paura a un pòvero curato, e impedirgli di compire il suo dovere, e per soverchiare[9] due innocenti. Lei può, con una parola, confonder coloro, restituire al diritto la sua forza, e sollevàr quelli a cui è fatta una così crudèl violenza. Lo può: e potèndolo . . . la coscienza, l' onore . . ."

"Lei mi parlerà della mia coscienza, quando verrò a confessarmi da lei. In quanto al mio onore[10] ha da sapère che il custode ne sono io, e io solo; e che chiunque ardisce entrare a parte con me in questa cura, lo riguardo come il temeràrio che l'offende." Fra Cristòforo, avvertito da queste parole che quel signore cercava di tirare al pèggio le sue, per vòlgere il discorso in contesa, e non dargli luogo di venire alle strette[11], s'impegnò tanto più alla sofferenza, risolvette di mandàr giù[12] qualunque cosa piacesse all'altro di dire, e rispose subito, con un tono sommesso: "Se ho detto cosa che le dispiàccia, è stato certamente contro la mia intenzione. Mi corregga pure, mi riprenda, se non so parlare come si conviene, ma si degni ascoltarmi. Per amòr del cielo, per quel Dio, al cui cospetto dobbiàm tutti comparire . . ." e, così dicendo, aveva preso tra le dita, e metteva davanti agli occhi del suo accigliato[13] ascoltatore il teschietto

di legno[14] attaccato alla sua corona, "non s'ostini a negare una giustizia così fàcile, e così dovuta a dei poverelli. Pensi che Dio ha sempre gli occhi sopra di loro, e che le loro grida, i loro gèmiti sono ascoltati lassù[15]. L' innocenza è potente al suo . . ."

"Eh, padre!" interruppe bruscamente don Rodrigo, "il rispetto ch' io porto al suo àbito è grande: ma se qualche cosa potesse fàrmelo dimenticare, sarebbe il vederlo indosso a uno che ardisse di venire a farmi la spia in casa." (Manzoni, "I Promessi Sposi," Cap. VI.) *Continued.*

NOTES. 1, In what can I oblige you? 2, planting himself; 3, be quick; 4, hesitating; 5, the beads of his rosary; 6, on this behaviour; 7, of others; 8, certain ill-conditioned men; 9, oppress; 10, regarding my honour; 11, to come to the point; 12, suffer; 13, frowning; 14, little wooden skull; 15, on high.

IRREGULAR VERBS

Second Conjugation—continued

Verbs in **ĕre** (short)—continued:

Prediligere, to love partially, to prefer
Past Def.—Predilessi, predilesse, predilèssero.
Past Part.—Prediletto.

Premere, to press (impers.: to be of importance)
Past Def.—The regular forms *premei, premesti,* etc., are more common than the forms *pressi, presse, prèssero.*
Past Part.—Premuto (*Presso*).

Presumere, to presume
Past Def.—Presumei, presumesti, etc. (regular), and *presunsi, presunse, presùnsero.*
Past Part.—Presunto.

Produrre (*prodùcere*), to produce [see *addùrre,* page 5082]

Proteggere, to protect
Past Def.—Protessi, protesse, protèssero.
Past Part.—Protetto

Pungere, to sting, to pique
Past Def.—Punsi, punse, pùnsero.
Past Part.—Punto.
Conjugate like *pùngere*: *compùngere,* to afflict.

Redimere, to redeem
Past Def.—Redensi, redense, redènsero.
Past Part.—Redento.

Reggere, to support
Past Def.—Ressi, resse, rèssero.
Past Part.—Retto.
Conjugate like *règgere*: *sorrèggere,* to sustain; *corrèggere,* to correct.

Reprimere, to repress
Past Def.—Repressi, represse, reprèssero.
Past Part.—Represso.

Ridurre (*ridùcere*), to reduce [see *addùrre,* page 5082]

Riflettere, to reflect
Past Def.—The regular forms *riflettei, riflettesti,* etc., are much more common than the forms *riflessi, riflesse, riflèssero.*
Past Part.—Riflettuto, considered; *riflesso,* reverberated.

Rifulgere (*poet.*), to shine
Past Def.—Rifulsi, rifulse, rifùlsero.
Past Part.—Rifulso.

Rilucere (*poet.*), to glitter, to shine
Past Def.—Rilussi, rilusse, rilùssero.
This verb has no Past Part.

Risolvere, to resolve
Past Def.—Risolvetti, risolvesti, etc. (regular), and *risolsi, risolse, risòlsero.*
Past Part.—Risoluto and *risolto.*

Scegliere, to choose (pron. *shèh'-lee-ehreh*)
Ind. Pres.—Scelgo, scegli, sceglie, scegliamo, sceglietc, scèlgono.
Past Def.—Scelsi, scelse, scèlsero.
Future—Sceglierò, sceglierai, etc. (*scerrò, scerrai,* etc.).
Imperat.—Scegli, scelga, scegliamo, scegliete, scèlgano.
Subj. Pres.—Scelga, scelga, scelga, scegliamo, scegliate, scèlgano.
Condit.—Sceglierei, sceglieresti, etc. (*scerrei, scerresti, scerrebbe,* etc.).
Past Part.—Scelto.
Conjugate like *scegliere*: *trascègliere,* to choose among; *prescègliere,* to select.

Sciogliere (*sciòrre*), to untie (pron. *shò'-lee-ehreh*)
Ind. Pres.—Sciolgo, sciogli, sciòglie, sciogliamo, sciogliete, sciòlgono.
Imperf.—Scioglievo, scioglievi, etc.
Past Def.—Sciolsi, sciolse, sciòlsero.
Imperat.—Sciogli, sciolga, sciogliamo, sciogliete, sciòlgano.
Subj. Pres.—Sciolga, sciolga, sciolga, sciogliamo, sciogliate, sciòlgano.
The forms *sciorrò, sciorrai,* etc., and *sciorrei, sciorresti,* etc., for the Future and Conditional instead of *scioglierò,* etc., *scioglierei,* etc., are only used in poetry.
Conjugate like *sciògliere*: *disciògliere,* to dissolve; *prosciògliere,* to free, to deliver.

Sconnettere, to disjoint, to be incoherent [see *connèttere,* page 5082]

Scorgere, to perceive [see *accòrgere,* page 5081]

Scrivere, to write
Past Def.—Scrissi, scrisse, scrìssero.
Past Part.—Scritto.
Conjugate like *scrìvere*: *descrìvere,* to describe; *inscrìvere,* to inscribe; *prescrìvere,* to prescribe; *ascrìvere,* to ascribe; *sottoscrìvere,* to subscribe; *circoscrìvere,* to circumscribe; *trascrìvere,* to transcribe.

EXERCISE L.

1. L'àlbero buono produce frutti buoni. 2. Quando scioglierò il pacco, potrete scègliere quello che più vi piace. 3. Che cosa avete scelto? 4. La domanda fu sottoscritta da circa cento persone. 5. Mio fratello mi ha scritto una lunga lèttera. 6. Se il signor N. non vi avesse protetto, ora non occupereste questo posto. 7. La pòvera bambina piange, perchè si è punto un dito con l'ago. 8. Premete il bottone, per chiamare il cameriere.

CONVERSAZIONE

Va sovente in casa N.?
Di quando in quando (now and then), e lei?
Quasi mai, ma i miei cugini ci vanno molto spesso.
A che ora ritorna?
Non so precisamente; verso le sette, credo. Ma se per le sette non sono ritornato, non mi aspettate; potrebbe darsi che vada a teatro.
Come sta la sua sorellina?
Molto mèglio, gràzie. Spero che fra qualche giorno potrà dirsi completamente guarita.
Si dice che la signorina N. sposi un ufficiale di marina; è vero?
Ma che; posso assicurarle che non ce n' è assolutamente niente.
Resta a pranzo con noi?
Volentieri; poi si andrà fuori insieme.

Key to Exercise XLVI.

1. You have done well to come to me; I shall easily get you out of trouble. 2. He always speaks modestly of himself. 3. Speak distinctly, if you wish me to listen to you. 4. Unfortunately we arrived too late. 5. Little by little we shall overcome all the difficulties. 6. Tell him to wait: I will come down at once. 7. Probably we shall have an answer this evening. 8. It was so dark that we went groping. 9. The bearer is an intimate friend of mine; I recommend him to you particularly.

Key to Exercise XLVII.

1. Come this way, sir; the way is much shorter. 2. Do you wish then that I should be compelled to ask here and there what has happened to my master? 3. One after the other all went away and left me alone. 4. If by any chance that gentleman who came yesterday should come, tell him that I am not in. 5. Who knows if we shall arrive in time. 6. Never promise if you are not quite sure to be able to keep your promise. 7. You have played enough; now it is time to go to bed. 8. It is possible that we shall meet in Milan in April or May. 9. If we walk so slowly we shall not be up there even by to-morrow. 10. Come down; the carriage is ready.

Key to Exercise XLVIII.

1. The reasons you have adduced do not justify your action. 2. The vault of this church was painted by a great artist. 3. The fire destroyed a great part of the building. 4. When they perceived my presence, they began to speak of something else. 5. I have been running about all day; now I want a little rest. 6. I cannot eat this meat: it is overdone. 7. Much has been already said on this subject. 8. Such a thick fog came down, that nothing could be distinguished. 9. The enemies (enemy) directed their fire against fort B. 10. Here is all we have been able to collect.

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FRENCH

By Louis A. Barbé, B.A.

PREPOSITIONS

The Prepositions in most frequent use are:

à, to, at
après, after
à travers, through
attendu, considering
avant, before (time)
avec, with
chez, at the house of
concernant, concerning
contre, against
dans, in
de, of, from, with
depuis, since
derrière, behind
dès, from, as early as
devant, before (position)
durant, during
en, in
entre, between
envers, towards
excepté, except
hormis, except
malgré, in spite of
moyennant, in consideration of
outre, in addition to
par, by, through
parmi, amongst
pendant during
pour, for, in order to
sans, without
selon, according to
sous, under
suivant, according to
sur, on, upon, about
sauf, save
touchant, concerning, touching
vers, towards
vu, seeing, considering

Remarks. The preposition *à* is used to form prepositional phrases, of which the most common are:

jusqu'à, till, to, as far as
par rapport à, with regard to
quant à, as for, as to
grâce à, thanks to

The preposition *de* is used to form the following prepositional phrases:

autour de, around, about
au-dessus de, above
au-dessous de, below
à l'égard de, with regard to
au-devant de, towards, to meet
à côté de, beside
du côté de, in the direction of
à force de, by dint of
à fleur de, flush with
auprès de, near
au delà de, beyond
à l'abri de, sheltered from
au-travers de, through
à moins de, unless
à l'insu de, unknown to
en dépit de, in spite of
en face de, facing
faute de, for want of
le long de, along
près de, near
proche de, adjoining
vis-à-vis de, opposite
au-dedans de, inside
au-dehors de, outside

2. The prepositions *à*, *de* and *en* must be repeated before every complement.

3. All prepositions except *en* require the verb coming after them to be in the infinitive. *En* is followed by the present participle: *Je suis bien loin de partager votre opinion*, I am very far from sharing your opinion. *Il ne partira pas sans venir nous voir*, He will not go away without coming to see us. *C'est en voyageant que j'ai appris la géographie*, It is by (in) travelling that I have learnt geography.

4. In, or at, when followed by the name of a town, is expressed by *à*. When followed by the name of a country, continent, or large island, it is expressed by *en*: *Il demeure à Paris*, He lives in Paris. *Son père est en France*, His father is in France.

5. Speaking generally, "in" is to be translated by *dans* when followed by an article, a possessive, or a demonstrative, and by *en* when there is no such determinative: *Elle rencontra un loup dans le bois*, She met a wolf in the wood. *En hiver la terre est couverte de neige*, In winter the ground is covered with snow.

6. Before expressions of time, *dans* expresses "time when," and *en* "time how long": *Je ferai cela dans une heure*, I shall do that in an hour's time (from now). *Je ferai cela en une heure*, I shall do that in an hour (it will take me an hour).

7. *Chez* means "at the house of," and requires no *de* after it: *S'il n'est pas chez lui, il est chez son cousin*, If he is not at his own house, he is at his cousin's.

8. *Durant* and *pendant* both mean during; but *durant* implies the whole of a period, and *pendant* a point of time during a period: *Nous sommes restés à Paris durant tout le siège*, We remained in Paris during the whole siege. *C'est pendant le siège que s'est livrée cette bataille*, It was during the siege that this battle was fought.

9. *Durant* may be placed after its complement: *Elle aura cette fortune sa vie durant*, She will have that fortune during her lifetime.

10. *Vers* implies actual movement towards: *Elle leva les mains vers le ciel*, She raised her hands towards heaven.

11. *Envers* is used figuratively, in connection with feelings, sentiments, etc.: *Il s'est montré reconnaissant envers nous*, He has shown himself grateful to (towards) us.

12. *Vers* also approximates "time when": *Nous arriverons vers midi*, We shall arrive about noon.

13. Approximation of "time how long," and of number or quantity generally, is expressed by

environ : Nous y resterons une heure environ, We shall remain there about an hour. *Nous avons fait environ dix milles,* We have walked about ten miles.

14. After a preposition, all personal pronouns must be in the disjunctive form: *Nous ne pouvons pas partir sans elle,* We cannot start without her.

15. Personal pronouns coming after a preposition usually refer to persons. Consequently, an English preposition followed by a neuter pronoun "it," "them," is commonly rendered by the corresponding adverb: *Ouvrons la boîte pour voir ce qu'il y a dedans,* Let us open the box to see what is in it.

EXERCISE XXXVII.

1. The sluggard (*paresseux*) works in spite of himself.
2. The sun shines for everybody.
3. Work with zeal; work is the source (*la source*) of wealth (*abondance*, f.) and joy (*la joie*).
4. The invention of the telephone (*le téléphone*) is due to Graham Bell, and that of the phonograph (*le phonographe*) to Edison.
5. From Calais, when the weather is clear (*clair*), you perceive Dover (*Douvres*) opposite you.
6. Learn that according to the saying (*le dire*) of one of the ancients (an ancient) we must eat to live, and not live to eat.
7. Write insults (*injure*, f.) on sand (*le sable*), and favours (*le bienfait*) on brass (*airain*, m.).
8. I fear God, and, after God, I mainly (principally) fe r those who do not fear Him.
9. We must try (*tâcher*) to live on good terms (*bien*) with everybody.
10. He works the whole week, except Sunday.
11. A well-bred (*élevé*) child must do nothing in despite of his parents.
12. The holidays (*vacances*, f. pl.) will begin in less than two months.
13. Perhaps your uncle does not know where our house is; go and meet him, and bring him if you see him.
14. One of Jules Verne's novels has for (its) title (*le titre*) "Around the (*le Tour du*) World in Eighty Days."
15. Let us put ourselves under this tree; we shall there be sheltered from the rain.
16. He owed his (the) life to the clemency (*la clémence*) and the magnanimity (*la magnanimité*) of the victor.
17. Fulfil your duties (*le devoir*) towards God, your parents, and your (the) native land (*la patrie*).
18. The same prejudices (*le préjugé*) are found in Europe, in Africa (*l'Afrique*), and even (as far as) in America.

CONJUNCTIONS

Simple conjunctions are not very numerous. The chief of them are:

car, for	*ni*, nor
cependant, however, yet	*non plus*, either
comme, as	*or*, now
donc, therefore, then	*ou*, or
et, and	*pourtant*, nevertheless, yet
mais, but	*quand*, though
si, if, whether	*puisque*, since
que, that	*quoique*, although

parce que, because

A great number of conjunctive phrases (*locutions conjonctives*) are formed by the addition of *que* to certain adverbs or to certain prepositions. Some of these are followed (*a*) by the indicative; others (*b*) by the subjunctive: and others (*c*) again by the indicative or the subjunctive according to their meaning:

(*a*)	(*b*)
à cause que, because	*afin que*, in order that
à ce que, according to what	*à moins que—ne*, unless
ainsi que, as	*avant que*, before
à mesure que, in proportion	*bien que*, although
après que, after	*de crainte que—ne*, lest
attendu que, considering that	*de peur que—ne*, for fear that
peut-être que, perhaps	*en cas que*, in case
tandis que, whilst	*non que*, not that
vu que, seeing that	*pour que*, in order that
au lieu que, whereas	*pourvu que*, provided
aussitôt que, as soon as	*sans que*, without
autant que, as much as	*soit que*, whether
depuis que, since	*supposé que*, supposing
dès que, as soon as	
pendant que, whilst	
outre que, besides	
tant que, so long as	
jusqu'à ce que, until	

(*c*) *de manière que*, in such a way that
de (en) sorte que, so that
si ce n'est que, except that
si non que, unless
tellement que, so that

These last conjunctions require the indicative when actual fact is indicated, and the subjunctive when a purpose or contingency is expressed:

Il a bien travaillé de sorte que son père est content de lui, He has worked well, so that his father is pleased with him. *Travaillez de manière que votre père soit content de vous,* Work in such a way that your father may be pleased with you.

Remarks. 1. The conjunction "for" meaning "because," must be carefully distinguished from the preposition "for" meaning "on behalf of," "instead of," etc.:

Ce n'est pas pour vous que j'ai acheté ces livres car vous ne lisez jamais, It is not for you I have bought those books, for you never read.

2. Conversationally, *mais* is frequently used simply to emphasise a statement, and may then generally be translated by "why": *Voulez-vous me prêter votre livre? Mais, certainement,* Will you lend me your book? Why, certainly.

3. *Que* is used to avoid the repetition of *comme*, as; *quand*, when; and *si*, if. In the last of these cases it is followed by the subjunctive: *Comme il fait beau temps et que nous n'avons rien à faire nous allons nous promener,* As it is fine and (as) we have nothing to do, we are going for a walk; *Quand il fait beau temps et que nous n'avons rien à faire nous allons nous promener,* When it is fine and (when) we have nothing to do, we go for a walk; *Si nous n'avons rien à faire et qu'il fasse beau temps nous irons nous promener,* If we have nothing to do and (if) it is fine, we shall go for a walk.

4. *Non plus* is equivalent to the English "either," at the end of a sentence: *Je ne le connais pas, ni son frère non plus,* I do not know him, or his brother, either.

5. *Puisque* and *depuis que* both mean "since"; but, the former introduces a motive, and is nearly synonymous with "because," whilst the latter refers to a point of time: *Je le lui donnerai, puisque je le lui ai promis,* I shall give it to him, since I promised it him; *Il m'a écrit deux fois depuis qu'il est en France,* He has written to me twice since he has been in France.

EXERCISE XXXVIII.

1. (The) Charity is patient, gentle and benevolent (*bienfaisant*).
2. The compass (*la boussole*) was not discovered (*trouver*) by a mariner (*marin*), nor the telescope (*le* ——) by an astronomer (*astronome*).

5. Neither (the) gold nor (the) greatness (*la grandeur*) make(s) us (*rendre*) happy.
4. (The) Man is unhappy only because he is wicked (*méchant*).
5. Obey (sing.) if you wish to be obeyed one day.
6. The swallows depart as soon as the first cold (pl.) comes (*arriver*).
7. A child is no longer believed when he has told a lie.
8. If (the) water boils sooner on (the) high mountains, it is because the pressure (*la pression*) of the air is less strong there.
9. All men are mortal: now, you are a man: therefore you are mortal.
10. If he comes to France and (if he) passes through Paris, I shall be delighted to see him.
11. The earth is never exhausted (*s'épuiser*), provided one knows (how to) cultivate it.
12. Behave (*se conduire*) in such a way that everybody is pleased with you.

INTERJECTIONS

Apart from a great many words and phrases that are frequently used as exclamations, the chief interjections are:

Ah! Oh!	*Gare!* Look out!
Aïe! Oh dear!	*Ha!* Ah!
Bah! Nonsense! Never mind!	*Hélas!* Alas!
Bis! Encore!	*Hein!* What? What's that?
Chut! Hush!	*Holà!* Hi!
Crac! Bang!	*Hum!* Hem!
Eh! Hallo!	*O!* O!
Fi! Fie!	*Pst!* Hist!

1. A frequent exclamation is *Dame!* Etymologically, it means "Lord!" from the Latin word "Domine." At the present day, it is absolutely meaningless, and is simply used to express hesitation or doubt, like the English "Well!" or "Why!"
2. An expression which is frequently heard, and which a literal translation quite fails to render, is *Mon Dieu!* It has about the same strength as the English "Goodness!" "My!" "Why!"
3. *Allons!* which literally means "let us go," is used like the English word "Come!"

Key to Exercise XXXVI.

1. Les hommes n'arrivent pas immédiatement à la connaissance de la vérité. 2. Il n'y a rien de plus fâcheux que l'incertitude. 3. Si nous avions seulement vécu deux siècles plus tôt nous n'aurions eu aucune idée des machines à vapeur, des chemins de fer, du télégraphe. 4. La paresse va si lentement que la pauvreté l'atteint bientôt. 5. La raison du plus fort est toujours la meilleure. 6. Les jeunes gens doivent parler peu et écouter beaucoup. 7. Le bonheur du méchant ne dure pas longtemps. 8. Ce voleur est accusé de s'être introduit nuitamment dans une maison. 9. Qu'il vienne vendredi ou samedi; ce sont les jours où je suis le plus ordinairement chez moi le soir. 10. Et maintenant, répondez-moi franchement, qu'y a-t-il de vrai dans cette accusation? 11. Je me suis toujours demandé pourquoi les Français, si spirituels chez eux, sont si bêtes en voyage. 12. Un bonheur extraordinaire a constamment accompagné ce brigand jusqu'à ce jour. Sa tête est mise à prix; pourtant il continue impunément son dangereux métier. 13. Il est extrêmement généreux: l'argent ne lui coûte guère à gagner, et il le dépense facilement avec les pauvres. 14. Il porte ordinairement un costume d'une très grande élégance; son linge est toujours d'une blancheur éclatante.

Continued

SPANISH Continued from page 5087 By Amalia de Alberti & H. S. Duncan

CONJUNCTIONS

Spanish conjunctions comprise a few simple conjunctions, and many compound conjunctive phrases which generally consist of adverbs or prepositions with *que*. Example: *de modo que*, so that.

Simple Conjunctions

The simple conjunctions are:

ni, nor	*y* (or *é*), and
ó (or *ú*), or	*pero*, *mas*, *sino* — but
que, that	
si, if	

1. *Y*, "and," becomes *é* before *i* or *hi*, but not before *hie*. Examples: *manzanas é higos*, apples and figs; *sabios é ignorantes*, learned and ignorant; *madera y hierro*, wood and iron.
2. *O*, "or," becomes *ú* before *o* or *ho*. Examples: *diez ú once*, ten or eleven; *muchacho ú hombre*, boy or man.
3. *Pero* and *mas* may be used indifferently to express "but," and can stand at the beginning of a sentence.
4. *Sino* is only used when the first clause contains a negative opposed by an affirmative in the second clause. Examples: *Es hermoso pero* (or *mas*) *no es joven*. He is handsome, but not young: *No es hermoso sino muy feo*, He is not handsome, but very ugly.

Compound Conjunctions

á fin que, in order that
á menos que, *á no ser que* — unless
antes que, before
así que, so that
aunque, although
bien que, although
caso que, in case that
como quiera que, however
con que, therefore, so then
con motivo que, so that
con tal que, provided that
cuanto más que, the more since
dado que, in case that
dado caso que, supposing that
de manera que, *de modo que*, *de suerte que* — so that
desde que, since
despues que, after
en tanto que, while, in case that
hasta que, until
luego que, as soon as
mientras que, while
no obstante que, notwithstanding
para que, in order that
porque, because
por mas que, however much
por menos que, *por poco que* — however little
pues que, *puesto que* — since, seeing that
siempre que, whenever
sin que, without
supuesto que, since, supposing that
tanto que, so that
ya que, now that, since

INTERJECTIONS.

Spaniards are always prodigal of exclamations and interjections. Besides the usual exclamations "Ah!" "Oh!" "Eh!" common to nearly all languages, the following are the most usual:

¡hola! to call attention, or a cry of welcome
¡chito!, *¡quedo!*, *¡calla!* — equivalents of "hush!"
¡vamos!, *¡vaya!*, *¡anda!* — to express surprise or incredulity
¡ay de mi! "Alas!"
¡ojalá! "Would that!" "Oh that!"

¡quita! | *¡dale!* | *¡dale que dale!* | *¡que demonio!* } to express impatience
¡arre! "Gee up!" (to horses)
¡zape! a word used to frighten cats

1. Familiar conversation is interspersed with exclamations of *¡hombre! ¡mujer! ¡hija!* etc. *¡Caramba! ¡canástro! ¡canario!* though inelegant, are constantly heard, and may be used without offence.

2. Religious exclamations are used with a freedom which might be considered profane in England; but in Spain such exclamations are perfectly proper and inoffensive, being equivalent to our "Good heavens!" or "Oh, dear me!" Those most frequently heard are:

¡Jesus! ¡Dios mio! ¡Dios de mi alma! ¡por Dios! ¡valgame Dios! ¡Virgen Santisima!

Vocabulary	Vocabulario
He is quite mad	¡Es loco rematado!
To finish	Rematar
High, loud	Alto
Great	Grande
White	Blanco
Underlinen	La ropa blanca
Wood	Leña, madera (f.)
The tips of the fingers	La yema de los dedos
The tip of the nose	La punta de la nariz
A cavalry soldier	Un soldado de caballeria
The club	El circulo, casino
The pulpit	El pulpito
The professorship	La cátedra
The professor	El catedrático
The dice	Los dados
He boasts of being a drunkard	Hace alarde de ser borracho
Mr. So-and-so	Don fulano
To be irritated	Amoscarse
A splinter	Una astilla
To elevate	Elevar
To raise	Alzar
To raise the voice	Levantar la voz
To erect	Erigir, levantar, construir
To erect a statue	Erigir una estátua
The entrance	La entrada
An entrée (dinner)	Un principio
To save, economise	Ahorrar, economizar
The postman	El cartero
The petty theft	La sisa
The pickled meat or pork	La chacina
The fish-hook	El anzuelo
A witticism	Una agudeza, un chiste
The glass	El vidrio
The crystal	El cristal
The tumbler	El vaso
The suburb	El barrio
The neighbourhood	La vecindad
The earthquake	El terremoto
The juice	El jugo
The vine	La viña

Exercise XXI (1).

Translate the following into Spanish:

1. Better late than never, but better early [pronto] than late. 2. I sent them money that they may be able to pay the cost of the journey, and unless they receive it in time I fear we shall not have the pleasure of seeing them. 3. Although I warned him that the speculation was risky, he invested large sums in that enterprise, and should (in case) he become bankrupt I shall have to be his surety, since he is my brother. 4. Hallo, friend! How are you? It is a long time since I saw you. 5. Since you will not come to see me here I am. As they say, if the mountain doe[s] not come to Mahomet, Mahomet goes to th[e] mountain.

Exercise XXI (2).

Translate the following into English:

1. Este hombre es muy alto—demasiado á n[i] parecer. Es casi un gigante. 2. Napoleon fué u[n] grande hombre apesar de ser pequeño de tall[a]. 3. Se lastíma uno las yemas de los dedos al toc[ar] el arpa. 4. Era hombre de saber, ocupaba un[a] cátedra en la universidad de Salamanca, y [se] consideraba como el primer catedrático de aquel[la] célebre universidad. 5. Ocupaba una posicion mu[y] elevada; se alzó de la nada. Fué el único q[ue] levantó la voz en defensa de la libertad de [la] prensa. 6. Las tropas despues de la guer[ra] hicieron su entrada en la capital con grand[es] aclamaciones del pueblo y le van á erigir un[a] estátua al General. 7. Don fulano se amoscó es[ta] mañana. ¿Quién es Don fulano? Nunca m[e] acuerdo de su nombre.

PROSE EXTRACT.

From "Notas Sobre el Comércio Hispan[o-] Británico en el Año 1904."

The raisins imported into Great Britain are of the following kinds and origin: The best from Malaga; the Valencia kind, which comes from Denia (Alicante); that called "Sultana," from Turkey; the Greek variety, commonly known in the trade by the name of currants (Corinth), and that from Australia, a new product, of which we shall speak later on.

Las pasas importad[as] en la Gran Bretaña s[on] de las siguientes clas[es] y procedencias: la s[u]perior, de Málaga; de Valencia, proceden[te] de Denia (Alicante); llamada "Sultana," [de] Turquía: la griega, con[o]cida vulgarmente en [el] comercio con el nomb[re] de "Corinto," y la [de] Australia, producto n[u]evo en este mercado, d[e] que se hablará más ad[e]lante.

The British Customs tariff groups them all in the same category, under the denomination of "Dried Fruits," together with figs, prunes, dates, and other dried or preserved fruits, although the tax makes a distinction between "currants"—that is, the Greek sort (or from Corinth)—and the "raisins"—*viz.*, those from Malaga and Valencia and the "sultana"; the first (currants) paying a duty of 2s. per English cwt. (50·80 kilos) and the others (raisins), 7s. per English cwt.

El Arancel de Aduan[as] británico las inclu[ye] todas en la misma pa[r]tida, bajo la denomin[a]ción de "Dried Fruits" juntamente con los hig[os,] ciruelas, dátiles y otr[as] frutas secas ó conserv[a]das, aunque el impues[to] divide las pasas en "cu[r]rants," esto es, las grieg[as] ó de "Corinto," y [los] "raisins" ó sea las [de] Málaga y Valencia "sultana"; pagando [el] derecho de 2 chelines quintal inglés (50[·80] kilos) las primeras (cu[r]rants) y 7 chelines quintal inglés las dem[ás] (raisins).

The principal reason of the remarkable difference in the tariff duty between the currants and raisins, and the burdening of the latter with a tax of 7s. per cwt., lies (apart from the Agreement between Greece and England, by which the duty on currants entering the

La razón principal la notable diferencia el derecho arancela[rio] entre los "currants" los "raisins" y de q[ue] las últimas se hall[en] gravadas con un derec[ho] de 7 chelines por quint[al] está (aparte del C[on]venio entre Grecia Inglaterra, por el c[ual]

United Kingdom is reduced to 2s., in exchange for a reduction in the import duty in Greece on certain English articles), in the fact that England tacitly extends the application of the alcoholic tariff to produce partially employed in the manufacture of artificial wines capable of being fermented and distilled in order to produce an imitation of genuine grape spirit.

During the present season (1904), the prices have experienced a drop of 8s. to 10s. per cwt., owing to the crop having turned out to be much larger than was anticipated, to the diminished demand from the Baltic markets, and to the great abundance of currants and sultanas.

Respecting the new raisin from Australia, this fruit has recently made its appearance in this kingdom, and some fairly important parcels have been received this year. The quality of this raisin is an imitation of the Valencia sort: and although, owing to the conservative disposition of the consumers and their attachment to custom, the reception at the beginning has not been very favourable, not a few people are of opinion that it is as good as the Valencia raisin. It is therefore almost certain that the public will soon get accustomed to it, and if Australia, as is to be supposed, increases her production to a considerable extent, it is possible that it may within a few years constitute a serious menace to the Valencia raisin, especially if England should come to grant preferential tariffs to Colonial produce, as the Protectionists are now demanding.

se rebaja á 2 chelines el derecho sobre los "Corintos" á su entrada en el Reino Unido, á cambio de la rebaja de derechos á la importación en Grecia de ciertos artículos ingleses) en el hecho de que Inglaterra extiende tácitamente la aplicación de la tarifa alcohólica á una producción parcialmente destinada á la fabricación de vinos artificiales, y que es susceptible de ser fermentada y destilada para producir la imitación de aguardientes legítimos de uva.

En la actual temporada (1904), los precios han sufrido un descenso de 8 á 10 chelines por quintal, debido á haber resultado la cosecha mucho mayor de lo que se calculó, á haber disminuido la demanda de los mercados del Báltico y á la gran abundancia de "corinto" y "sultana."

Respecto á la nueva pasa de Australia, esa fruta ha hecho su aparición en este reino recientemente, y se han recibido este año algunas cantidades de relativa importancia.

La calidad de esta pasa es una imitación de la de Valencia; y aunque, dado el espíritu conservador de los consumidores y su relativo apego á la costumbre, la acogida que se le ha hecho en un principio no ha sido muy favorable, no son pocos los que opinan que es tan buena como la de Valencia. Es, pues, casi seguro que el público se acostumbrará pronto á la misma, y si Australia, como es de presumir, aumenta su producción en grandes porciones, dentro de algunos años puede ser un grave peligro para la pasa de Valencia, especialmente si Inglaterra llegara á conceder ventajas arancelarias á los productos coloniales, como pretenden los proteccionistas.

KEY TO EXERCISE XX (1).

1. A la hora de comer, antes de la sopa, bajo el pretexto que la mesa no estaba bien puesta, con la mano dió un golpe contra la lampara, y la volcó.

2. Durante una tormenta el miedo la hizo desmayarse.

3. Segun me han dicho, no cabe duda que el Señor A. se marcha mañana.

4. Apesar de no querer tener amistad con ella, fui á verla.

5. A las diez de la noche vino á verme y me ofreció estos cuchillos á diez duros la docena.

6. Al anochecer saldrémos en coche.

7. Amo á esa mujer: quiero á su perro; y aborrezco á su familia.

8. Esta agua sabe á tierra.

9. Poco á poco, se fueron, uno á uno.

10. ¿Como le gusta á Vd el café, á la turca, ó á la francesa?

11. ¿Como fué Vd al campo, á pie? Fui á caballo.

12. ¿Puede Vd comer conmigo mañana? No, salgo para Paris mañana por la mañana.

13. Ademas de este portamoneda me dió este lapiz de plata.

14. Debajo de los árboles hay sombra, y es bueno que estén delante de la casa.

15. Dentro de la casa hay muebles exquisitos, y da pena pensar que despues de tantos años se han de vender: la venta tendrá lugár en el césped detrás de la casa.

16. Lleva encima de sus hombros un pañolon que vale una fortuna.

17. Su ignorancia está á la vista de todos.

KEY TO EXERCISE XX (2).

1. At the end of twenty years, when we believed him dead, he returned home. 2. Instead of coming himself he sent his delegate. 3. Because of his misfortune I forgave his offence. 4. As to what you told me I have learnt that it is not true. 5. The water came down over the mountains in cataracts, destroying everything, and death surprised those poor people in the midst of their joy. 6. Beyond the high road you will find the lane that leads to the fountain. 7. Notwithstanding he was told never to come back, he came this morning. 8. He left his father's home never to return. 9. He brought me a letter from my lawyer: the case is going badly.

Continued

ESPERANTO

Continued from page 5088

By Harald Clegg

DEGREES OF COMPARISON

Adjectives. The degrees of comparison in Esperanto are absolutely regular, and are formed by placing the words *pli* (more) and *plej* (most) before the words which are to be compared.

COMPARATIVE OF SUPERIORITY.

Pli . . . ol (than).

Example: *Ŝi estas pli bela, ol vi.* She is more beautiful than you.

SUPERLATIVE OF SUPERIORITY.

Plej . . . el (of, out of, among).

Example: *Li estas la plej altkreska, el la familio.* He is the tallest of the family.

COMPARATIVE OF INFERIORITY.

Malpli (less) . . . *ol* (than).

Example: *Li estas malpli forta ol mi.* He is less strong than I.

Superlative of Inferiority.

Malplej (least) . . *el* (of, out of, from, among)

Example: *Li estas la malplej forta, el la familio*, He is the weakest of the family

Comparison of Equality

Tiel (as, so) . *kiel* (as)

Example: *Mia domo estas tiel granda kiel via*, My house is as big as yours.

Superlative Absolute

Tre (very)

Example: *Vi estas tre agrabla*, You are very agreeable

All these comparisons can be negatived by the insertion of *ne* (not) before the verb Examples

Li ne estas la plej riĉa homo en la urbo, He is not the richest man in the town

Ŝi ne estas tre bela, She is not very beautiful

Sometimes it will be found that, when the verb is transitive, the noun or pronoun following *ol* being the direct object of that verb must, like the adjective, be placed in the accusative, and this must be carefully watched, or ambiguity in the meaning will arise

In the English sentence, "I saw him more angry than you," there are two possible constructions but thanks to the accusative *n* in Esperanto, which here again vindicates its usefulness, the ambiguity is removed If we mean, "He was more angry than you," the above sentence would be translated *Mi vidis lin pli koleran ol vin*, because here *vin* is, with *lin*, the direct object of the verb *vidis* But if the meaning is "He appeared to me more angry than to you," the sentence must be translated *Mi vidis lin pli koleran ol vi*, because in this case *vi* is also the subject of the verb *vidis*

Before adjectives *plej* is, as a rule preceded by the article *la*

The word *tre* (very) is often used before verbs to represent the English "much," but it is quite permissible to use, if desired, the two words *tre multe* Example

Mi tre (*multe*) *timas, ke li mortos*, I very much fear that he will die.

Adverbs. Adverbs are compared in exactly the same manner as adjectives and follow the same rules. Examples:

La viro frapas pli forte, ol la knabo, The man strikes harder than the boy

Mi parolas tre laŭte, vi parolas pli laŭte, sed mia frato parolas plej laŭte, I speak very loudly, you speak more loudly, but my brother speaks most loudly

Ŝi amas lin pli multe, ol vi, She loves him more than you (do)

Ŝi amas lin pli multe, ol vin, She loves him more than (she loves) you

NUMERALS

Collective Numbers.

The collectives are formed regularly from the cardinals by adding the suffix *op*, and then, by the further addition of *o*, *a*, or *e*, nouns, adjectives or adverbs are obtained respectively Example

Mi timas ilian duopan atakon, I fear their double attack

VOCABULARY

ador', adore
alt, high, tall
bedaŭr', be sorry (for) regret
bril', shine
difekt', damage, injure
direkt', direct, steer
disput', dispute
diskut', discuss
divid', divide
esprim', express (v t)
faden', thread
fart', be (in health)
fier', proud
fortik', sturdy, robust
graci', graceful
ĝentil', polite
ĝust', exact, right
ide', idea
interes', interest (v t)
jar', year
ĵaluz', jealous
komenc', commence (v t)
konfes', confess, acknowledge
konsent', consent
konsil', advise, counsel
konstru', construct, build
kre', create
kresk', grow (v i)
kruel', cruel
lac', weary, tired
land', land country
liber', free
lok', place locality
metod', method
mir', wonder
mond', world
nombr', number (subst)
oportun', opportune, convenient
pan', bread
pardon', pardon
pens', think
perd', lose
plen', full
plezur', pleasure
plum', feather (or pen)
pord', door
renkont', meet, encounter
sovaĝ', savage wild

Exercise VIII

I very much regret to hear about your brother's death I am told that you are not so well to day as you were yesterday Although the king is graceful and robust, he is proud and as cruel as the wildest animal. Our country is the most dear and beautiful in the whole world. I do not think that I am jealous, but I truly believe that she adores me more than you They commenced to discuss freely and dispute about our methods, but I must confess that I could not express my approval Can you direct me to the theatre? Yes, sir, with pleasure Here it is, on the left hand The sun high in the heavens warmly shines I am just as tired as yourself, but not so impolite He built a high house out of stone Your idea is very good and interesting, but it is inconvenient In our country the people are free They unfortunately lost a great number of friends I wonder that I did not meet you and your friend together I pardoned him, but he proudly went away and shut the door Flowers grow during the whole year

Key to Exercise VII

Dum la nebula vetero kaj la malvarmaj vintraj tagoj mi restis hejme kaj lernas leciono ju pri Esperanto Mi povas kalkuli de unu ĝis centmil sen malfacile Tamen ĉu la tempo estas malonga, kaj mi havas multon per fari, mi penos konvinki vin morgaŭ se vi konsentos Ĉu vi volis korespondi kun mi? La nuboj estas tre nigraj malvarma vento blovas sed mi esperas ke mi ne vidos negon hodiaŭ Mi audas per miaj (or, la) oreloj kaj vidis per miaj (or la) okulo Kvankam li ricevis multajn donacojn (or, multe da donacoj), li estis tre malkontenta Li estas tre ne sed li estis tamen nature humila kaj modesta Nia najbaro estas tre malmodesta kaj malkuraĝ La leciono estis mallonga kaj knaboj ĝin lernis parkere Ĉu la vento blovis malforte, la ondo sur la maro estis malgrand kaj mi ne estis malsana Ĉu li diris al vi, ke li intencas sin oku pri Esperanto? Oro kaj argen estas tre neçesaj La botoj de soldato estas mallarĝaj, sed estas longaj La rivero fluas t largaj kampoĵ ĝis la maro N nova najbaro mortis en la me de la nokto Lia maniero est tre stranga, sed antaŭ ol morti penis konvinki min, ke li posed multe da oro kaj arĝento Ĉu ne diris al vi, ke li nepre pag vin morgaŭ?

Continued

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